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GEOLOGICAL REPORT ON THE COPPER LANDS OF LAKE SUPERIOR LAND DISTRICT, MICHIGAN.

LETTER

FROM

THE SECRETARY OF THE INTERIOR,

ENCLOSING

The geological report on the copper lands of Lake Superior land district, Michigan.

May 16, 1850.

Referred to the Committee on Public Lands, and ordered to be printed.

June 14, 1850.

10,000 copies extra ordered to be printed.

Department of the Interior,
Washington, April 29, 1850.

Sir: I have the honor to communicate, herewith, a letter from the Commissioner of the General Land Office, transmitting the report of Messrs. Foster and Whitney, United States geologists, on the copper lands of the Lake Snperior land district, Michigan.

I have the honor to be, very respectfully, your obedient servant,

T. EWING, *Secretary.*

Hon. Howell Cobb,
Speaker of the House of Representatives.

General Land Office, *April* 26, 1850.

Sir: I have the honor to communicate, herewith, a report from Messrs. Foster and Whitney, United States geologists, on the "copper lands" of the Lake Superior land district, in Michigan, accompanied by a number of views of the principal features of that interesting region, with diagrams of the mines, &c., illustrating the work. There is, also, accompanying this report, a *fac-simile* of a map of Lake Superior and the adjacent regions, made by the Jesuit missionaries in 1670 and 1671, and published at Paris in 1672.

This report contains a vast fund of valuable information, and the publication of it will be an important addition to the cause of science. It would have been communicated with my annual report, but the time since those gentlemen were appointed was too short to enable them to

prepare it in season. It is now submitted as supplementary to that report, and I respectfully request that it may be so communicated to Congress.

With much respect, your obedient servant,

J. BUTTERFIELD, *Commissioner.*

Hon. Thomas Ewing,
Secretary of the Interior.

Boston, *April* 15, 1850.

Sir: We herewith present to you a report on the "copper lands" of the Lake Superior land district. When it is considered that this district embraces an area of more than sixteen thousand square miles; that nearly the whole of that area is an unbroken wilderness; that we were required to explore considerable portions of it with sufficient minuteness to designate the character of each quarter section; and that, in the accomplishment of this object, our camp equipage and provisions, and even our canoes, were carried for long distances on the backs of men; and that the limited state of our supplies often compelled us to press on without regard to weather—under these circumstances, we trust we shall be pardoned if it be found that we have fallen into minor errors, or hastily passed some points which were deserving of a more minute examination. In the delineation of the main features of the region, we trust that this report will be found correct.

With sincere thanks for the aid afforded us in the prosecution of these researches by several of the officers attached to the bureau over which you preside, we subscribe ourselves,

Sir, with great respect, your most obedient servants,

J. W. FOSTER,
J. D. WHITNEY,
United States Geologists.

To Hon. Justin Butterfield,
Commissioner of the General Land Office.

REPORT

ON THE

GEOLOGY AND TOPOGRAPHY

OF A PORTION OF THE

LAKE SUPERIOR LAND DISTRICT,

IN

THE STATE OF MICHIGAN:

BY

J. W. FOSTER AND J. D. WHITNEY,
UNITED STATES GEOLOGISTS.

IN TWO PARTS.

PART I.
COPPER LANDS.

WASHINGTON:
PRINTED FOR THE HOUSE OF REPS.
1850.

REPORT

ON THE

GEOLOGY AND TOPOGRAPHY

OF A PORTION OF

THE LAKE SUPERIOR LAND DISTRICT,

IN

THE STATE OF MICHIGAN.

INTRODUCTION.

Historical sketch.—Raymbault and Jogues's voyage to Saut. Ste: Marie.—René Mesnard visits Lake Superior.—Alloüez follows.—Dablon and Marquette follow.—Grand Council.—Marquette proceeds to Green Bay.—Discovers the Mississippi.—His death.—Alloüez's death.—Early map of this region.—Effect of the Missionary labors on the Indians.—Travels of Hennepin; Charlevoix; Henry; Mackenzie.—Expedition of General Cass; of Schoolcraft; of Maj. Long.—Dr. Houghton; his labors and death.—The treaties by which this district was ceded.—The several acts of the government in reference thereto.—The act authorizing the survey.—Its organization.

The first steps towards the exploration of the country bordering on the great chain of North American lakes were taken by the Jesuits of Canada, more than two centuries ago, under the auspices of Count Frontenac, then governor general of that region.

On the 7th of September, 1641, Charles Raymbault and Isaac Jogues, two missionaries of the order of Jesus—an order whose memorials are to be found in every quarter of the habitable earth—accompanied by several Hurons, left the bay of Pentanguishene in a bark canoe for Saut Ste. Marie. At the head of this bay they had established a mission. It formed, at that time, the western terminus of the travelled route between Montreal and Lake Huron, by way of the Ottawa river and Lake Simcoe, and for years afterwards, while the power of France in the Northwest remained in the ascendant, constituted an important link in a chain of posts extending for more than two thousand miles.

The route of Raymbault and Jogues lay through the Georgian bay, and thence among the countless islands that stud the channel of the St. Mary's

river. After a voyage of seventeen days they arrived at the falls (Saut,) where they found an Indian village with a population of two thousand souls. The abundance of white fish, and the facilities for capturing them in the foaming rapids, have made this the chosen resort of the Chippewas for centuries. The chiefs received them kindly and invited them to dwell in their midst. "We will embrace you as brothers," they said, "and profit by your words."

They here learned of the existence of a lake still beyond, called by the Indians Kitchi-gummi, (Big lake,) surpassing in magnitude either Huron or Michigan, then called Illinois, beyond whose western limits was a country destitute of trees, but covered with grassy plains, through which roamed herds of buffalo and deer.

Here dwelt the Sioux or Nadouessi, a race at once warlike and indomitable. At that day a feud existed between the two tribes, which has been perpetuated to the present time.

Late in the season Raymbault returned to Pentanguishene with the intention of revisiting the Saut in the succeeding spring, and establishing there a permanent mission; but consumption, brought on by repeated exposures and privations, was fast hurrying him to the grave. The following year he returned with Jogues to Quebec, where he died October 22, 1642. Father Jogues started to return, but in ascending the St. Lawrence was captured by the Mohawks, a predatory band infesting the shores and tributaries of Lake Erie. After having been subjected to the most ignominious treatment, himself scourged, and his Huron attendants committed to the flames, he was ultimately ransomed by the Dutch in the vicinity of Albany. He revisited France, but soon returned to the scene of his labors with a spirit unabated and a zeal unquenched.

René Mesnard followed in the track of Raymbault. On the 28th of August, 1660, he left Quebec, taking with him a scanty stock of necessaries; "for I trust," said he, "in that Providence which feeds the little birds of the air, and clothes the wild flowers of the desert." He was past the meridian of life, but possessed all the zeal of youth. He went forth with the presentiment that he was performing his last journey, for, in writing back to a friend, he remarked: "In three or four months you may add my name to the memento of deaths." Having arrived at the Saut, he proceeded to coast along the southern shore in a canoe, and on the 15th of October reached the head of Keweenaw bay, which he named St. Theresa—the day of his arrival being the anniversary day of that patron saint. Here he remained until the following spring, when he left, accompanied by a single Indian, for Chaquamegon bay, near the head of the lake. They took the route through Portage lake; and while the voyageur was conveying the canoe across the portage, the good Father wandered into the woods, and no trace of him was afterwards obtained. This happened August 20, 1661. The world applauds the heroism of Columbus who launched out upon a trackless ocean in search of a new world. The humble missionary who, committing himself to the guidance of savage attendants, voyaged for days with a boundless waste of waters on one side, and on the other an unbroken wilderness, showed a degree of courage and enthusiasm which has rarely been rivalled, and which ought to rescue his name from oblivion.

Claude Alloüez followed in his footsteps. On the 8th of August, 1666, he embarked at Three Rivers, accompanied by four hundred Indians,

who were on their return from Quebec. In the beginning of September he arrived at the Saut, and entered Lake Superior, "which," said the good missionary, "shall henceforth bear the name of M. de Tracy, in token of the obligations the people of this region are under to him;" and this is the name applied to it on the earliest map.

"The savages," he continues, "respect this lake as a divinity, and offer sacrifices to it because of its size, for it is two hundred leagues long and eighty broad, and also in consequence of its furnishing them with fish, upon which all the natives live when hunting is scarce in these quarters. * * * It happens frequently that pieces of copper are found, weighing from ten to twenty pounds. I have seen several such pieces in the hands of savages; and since they are very superstitious, they esteem them as divinities, or as presents given to them to promote their happiness by the gods who dwell beneath the water. For this reason they preserve these pieces of copper wrapped up with their most precious articles. In some families they have been kept for more than fifty years; in others, they have descended from time out of mind—being cherished as domestic gods.

"For some time there was seen near the shore a large rock of copper with its top rising above the water, which gave an opportunity to those passing by to cut pieces from it; but when I passed that vicinity it had disappeared. I believe that the gales which are here frequent, like those of the sea, had covered it with sand. Our savages tried to pursuade me that it was a divinity who had disappeared; but for what cause they were unwilling to tell."* He passed the bay called by Father Mesnard St. Theresa, where he met "two Christian women, witnesses of his (Mesnard's) labors, who had preserved their faith, and sparkled like two stars in the midst of the darkness of infidelity. Having refreshed their memories with our mysteries, we proceeded on. After having travelled one hundred and eighty leagues along the border of the lake, on the southern side, where the Lord hath often tried our patience by means of gales, famine, and fatigue, both day and night"—many a poor voyageur has since uttered the same complaints—"we landed on the 1st of October at Chaquamegon." This is the old La Pointe of the voyageurs. He describes it as a beautiful bay, on whose margin dwelt numerous savages: their warriors amounting to eight hundred. Here he paused in his wanderings, erected a chapel, and commenced the work of winning the savages to the standard of the cross. He found that the Chippewas were meditating a warlike expedition against their ancient enemies, the Sioux. He was permitted to advise, and succeeded in diverting them from the enterprise. Here he dwelt for two years. His fame reached the surrounding tribes, who gathered around to satisfy their curiosity and receive the benefit of his instruction. During this period he visited Fond-du-Lac, where he met with some of the Sioux, who informed him of a country to the west abounding in prairies, over which roamed the buffalo, and that there was a great river called Messepi, (Mississippi,) whose banks were inhabited by the beaver. He extended also his mission among the Nipissiriniens, on the north shore of the lake.

In the fall of 1667 he returned to Quebec to procure aid in establishing missions in the Northwest; and such was his ardor, that in two days after his arrival he was on his way back to his forest home.

*Charlevoix, in his Travels, has appropriated almost verbatim Allouez's description.

In 1668 Claude Dablon and James Marquette proceeded to Saut Ste. Marie for the purpose of establishing a permanent mission. Of the personal history of the former little is known, but the latter was in the prime of life, highly educated, and fitted to adorn the court of Louis; but he sacrificed all of these advantages, and passed his life among a race comparatively low in the scale of intellectual organization. From this period Saut Ste. Marie dates its settlement; and it is therefore, as Bancroft remarks, the oldest within the limits of the State of Michigan.

The following year Marquette succeeded Alloüez at La Pointe, and the latter removed to Green Bay.

In May, 1671, a grand council assembled at Saut Ste. Marie. The chiefs from fourteen of the tribes of the Northwest and the soldiers of France sat in council together. Mr. Tallon, then governor general of New France, had sent there Monsieur de St. Lusson to take possession, in the name of his Majesty, of all lands lying between the east and west, and from Montreal to the South sea, as far as it could be done. When assembled, the ambassador selected a hill above the village, planted the cross, and raised the arms of the King. The cross was first blessed with all the ceremonies of the Church by the Superior of the missions; and while it was being raised, the *Vexilla* was chanted by the assembled Frenchmen, to the great admiration of the savages. The shield of France was suspended from a cedar post above the cross while they were chanting the *Exaudiat*, and prayers were offered for the sacred person of his Majesty. St. Lusson formally took possession of the lands; after which guns were discharged, and other manifestations of joy exhibited. Father Alloüez was present, mindful of the interests of his divine as well as temporal master.* The same year Marquette removed to St. Ignace, north of Mackinac. Here he built a chapel, and gathered about him the wandering Hurons. Marquette and Dablon made numerous excursions to the tribes which dwelt in the territory now embraced in northern Illinois and eastern Wisconsin. Marquette, like Alloüez, had heard marvellous accounts of the region beyond the Great Lake, and longed to explore it; but it was not until the year 1673 that he was enabled to carry his project into execution. His route lay up the Fox river, through Lake Winne-

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*Alloüez pronounced the following panegyric on the King, which is worthy of being preserved:

"It is a most important affair which calls us together. Cast your eyes on that cross, which is so high above your heads. 'Tis there where the Son of God was willing to be attached and to die, in order to satisfy His eternal Father for your sins. He is the master of our lives, and also of heaven, and earth, and hell. It is He of whom I have so often spoken, and whose name and word I have borne into these distant lands. But, at the same time, look upon that other column, to which are attached the arms of that great chief of France, whom we call King. He lives beyond the sea. He is the chief of chiefs, and has not his like in the world. All the chiefs whom you have seen, and of whom you have heard, are but children compared with him. He is like a great tree, while they are mere shrubs which we tread upon. You know Onnontio, (governor general,) the renowned chief of Quebec. You know that he is the terror of the Iroquois, and that his name is sufficient to make them tremble, since he has desolated their lands, and carried fire among their settlements. There are beyond the sea ten thousand Onnontios like him, who are but warriors of that great chief, our King, of whom I speak. When he says 'I go to war,' everybody obeys, and these ten thousand chiefs raise bands of warriors both for the land and for the sea. Some embark in ships, like those you have seen at Quebec. Your canoe will hold but four or five men—twelve to the utmost. Our vessels carry four and five hundred, and even a thousand. Another portion go to war on land, but in such numbers that, when arranged in double ranks, they would reach to Mississaquenk, which is twenty leagues from here. When he attacks, he is more fearful than thunder. The earth trembles, and the air and the sea are on

bago, and thence down the Wisconsin into the Mississippi. In this expedition he was accompanied by Joylet, a courtier of France. They descended the mighty current as far as Arkansas, and then turned back. They represented that they were hospitably entertained by the Illinois, who dwelt upon its banks, while by other tribes they were repulsed.

This relation of the voyage of Marquette was not published until some time after his death, and by some it is regarded as fabulous; but Bancroft is disposed to adopt it as worthy of entire credence.

Late in the season the voyageurs reached Chicago. Joylet hastened to Quebec to announce the results of their discoveries, while Marquette remained to plant the standard of the cross among the Miamies.

The manner of his death is thus narrated by Bancroft: "In sailing from Chicago to Mackinac during the following spring, he entered a little river in Michigan. Erecting an altar, he said mass after the rites of the Catholic church; then, begging the men who conducted his canoe to leave him alone for half an hour,

> 'In the darkling wood,
> Amid the cool and silence, he knelt down,
> And offered to the Mightiest solemn thanks,
> And supplication.'

At the end of half an hour they went to seek him, and he was no more. The good missionary, discoverer of a world, had fallen asleep on the margin of a stream that bears his name. Near the mouth, the voyageurs dug his grave in the sand."* This event happened May 18, 1675.

Alloüez died soon after in the midst of his labors among the Miamies.

The Jesuits made a map of this region as early as 1669, which was published in 1672. We suspect that it is the work of Alloüez and Marquette, but it bears no name. Dablon thus speaks of it: "It was got up by two Fathers, very intelligent and observing, who did not wish to incorporate anything except what they had seen with their own eyes. That is the reason why they have only inserted the upper part of Lakes Huron and Illinois, although they have coasted much on both."

When it is considered that these men were not engineers, and that to note the geographical features of the country formed no part of their requirements, this map may, for that age, be regarded as a remarkable production, although points occasionally are laid down half a degree from their true position. The whole coast, sixteen hundred miles in extent, as well as the islands, were explored. Even Caribou, a low island in the midst of the lake, and not visible except within a few leagues, did not escape their observation.

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fire from the discharge of his cannon. He has been seen in the midst of his squadrons covered with the blood of his enemies; so many of whom has he put to the sword, that he does not number their scalps, but merely the rivers of blood which he has caused to flow. He carries such a number of captives with him that he does not value them, but lets them go where they please, to show that he does not fear them. Nobody dare make war on him. All nations beyond the sea have sued for peace with great submission. They come from every quarter of the globe to listen to him and admire him. It is he who decides upon the affairs of the world. What shall I say of his riches? You think yourselves very rich when you have ten or twelve sacks of corn, and hatchets, and kettles, and other things of the kind. He has more cities than you have men, which are scattered over a space of more than five hundred leagues. In each city there are shops containing hatchets enough to cut all your wood, kettles enough to cook all your caribou, and sugar enough to fill all your wigwams. His house extends further than from here to the Saut, is higher than the tallest of your trees, and contains more people than the largest of your settlements ever contained."

* History of the United States, volume I.

Alloüez, Marquette, and Jogues were remarkable men, and, had their lots been cast in a different sphere, they would have left a more durable impress upon the age in which they lived. Their efforts to win the tribes of the Northwest to the standard of the cross, prosecuted with great zeal, and under circumstances of privation and suffering, may be regarded as abortive.

There is something impressive in the rites of the Catholic church—something in its mysteries calculated to overawe the wild men of the woods. So long as the missionary was in their midst and superintended their labors, they yielded to his guidance and adopted his recommendations, so far at least as conduced to their comfort; but when he withdrew, with equal facility they glided into their former habits. The superstructure raised with so much care fell to the ground the moment the sustaining hand was withdrawn. The effect of the contact of the two races has been to afford the Indian additional incentives to vice, while his intellectual and moral elevation has been little advanced; and at this day, it cannot be said that he stands higher in the scale of civilization than when first known by the white man.

Such knowledge as we possess with regard to the early discoveries in the Northwest is derived from the "Relations de ce que s'est passé de plus remarquable aux Missions des pères de la compagnie de Jesus en la Nouvelle France." They are comprised in many volumes, to be found in the library of Harvard College.

The occurrence of native copper naturally excited the wonder of the first voyageurs, and the references to it are numerous. The first mention is made in the Relation for 1659-'60. An Indian, named Awatanick, who had passed from Green Bay to Lake Superior the year previously, reported "that its borders were enriched with lead mines, and copper of such excellent quality that it is already reduced in pieces as large as the fist. There may also be seen rocks which contain large veins of turquoise," (green silicate of copper.)

The relator adds that he has heard of the existence of gold on St. Joseph's island, and that the rivers of Lake Superior bring down grains of gold.

Another relator states that diamonds occur on some of the islands at the foot of Green Bay.

In the Relation for 1669-'70, Father Dablon says: "We have learned from the savages some secrets which they did not wish at first to communicate, so that we were obliged to use some artifice. We do not, however, vouch for everything contained in the following account. After entering the lake, the first place met with containing copper is an island about forty or fifty leagues from the Saut, towards the north shore, opposite a place called Missipicooatong, (Michipicoten.) The savages relate that it is a floating island, being sometimes near and at others afar off. A long time ago four savages landed there, having lost their way in a fog, with which the island is frequently surrounded. It was previous to their acquaintance with the French, and they knew nothing of the use of kettles and hatchets. In cooking their meals, as is usual among the savages, by heating stones and casting them into a birch-bark pail containing water, they found that they were almost all copper. After having completed their meal, they hastened to re-embark, for they were afraid of the lynxes and hares, which here grow to the size of dogs. They took with

them copper stones and plates, but had hardly left the shore before they heard a loud voice exclaiming in an angry tone, 'Who are the thieves that carry off the cradles and the toys of my children?' They were very much surprised at the sound, not knowing whence it came. One said it was the thunder; another that it was a certain goblin called Missibizi, the spirit of the waters, like Neptune among the heathen; another that it came from the Memogovissioois, who are marine men, living constantly under the water, like the Tritons and Syrens, having long hair, reaching to the waist; and one of the savages asserted that he had actually seen such a being. At any rate, this extraordinary voice produced such fear that one of them died before landing; shortly after, two others died, and one alone reached home, who, after having related what had happened, also died. Since that time, the savages have not dared to visit the island, or even to steer in that direction." The Father attempts to explain this superstition by supposing that they were poisoned by using the copper boulders in cooking their meat, and that the supernatural voice was an echo of their own, and that the vanishing and reappearance of the island was due to fogs and haze which hang about it. He concludes by adding that it is a common belief among the savages that the island contains an abundance of copper, but that no one dare approach it.

"Pushing along to Le Grand Anse, (Neepigon bay,) we come to an island called 'Thunder island,' which is noted for its abundance of metal. (This is probably St. Ignace.) Further to the west is an island called Menong, (Isle Royale,) celebrated for its copper. It is large; being twenty-five leagues long and seven leagues distant from the main land. One bay at the northeast extremity is particularly remarkable. It is bounded by steep cliffs of clay, in which there may be seen several strata or beds of red copper separated from each other by layers of earth. In the water is seen copper sand, which may be gathered with spoons, although there are pieces as large as acorns. This large island is surrounded by several smaller ones, some of which are said to consist entirely of copper. One, especially, near the northeast corner, is within gunshot of the main island. Further off in that direction is one called Manitou-minis, on account of the abundance of copper. It is said by those who have visited it, that on a stone being thrown against it, a sound like that of brass when struck is heard.

"After having reached the extremity of the lake, there may be seen (one day's journey) on the south shore, by the water's edge, a mass of copper weighing 600 or 700 lbs., so hard that steel cannot cut it; but when heated it may be cut like lead."

On one of the islands near Chaquamegon bay, he relates that copper rocks and plates are found, and that he bought of the savages a plate of pure copper two and a half feet square, weighing more than 100 lbs. He supposes that they have been derived from Menong, and that their transport has been effected either by floating ice or by powerful winds from the northeast, which have rolled them along the bottom of the lake.

He mentions the fact that the Ottawa squaws, in digging holes in the sand to hide their corn, often find masses weighing 20 or 30 lbs. "Near the river Nantonagon (Ontonagon) may be seen a bluff, from which stones of red copper fall down into the water. Three years since we were presented with a piece from that locality weighing 100 lbs. We have cut some pieces from it, and sent them to Talon, at Quebec. The savages do

not all agree as to the place whence it is derived. Some say that it is where the river begins; others, that it is close to the lake, in the clay; and others, at the forks, and along the eastern branch of the river.

"Further on is found the long spit, (Keweenaw Point,) which we have compared to the arrow of the bow. At its extremity is an island six feet square, which is said to be entirely of copper. Finally, to complete this survey of the Great Lake, we would add, that it is stated that mines of the said metal are found in several places to the south. All these circumstances, together with others which it is not necessary to mention, are deserving of an attentive examination. We would also mention an oxide of copper, which is said to come from the crevices of certain rocks, (Pictured Rocks,) and the occurrence of certain pebbles along the shore, which are somewhat soft and of an agreeable green color. If God prospers our undertaking we shall speak about it next year with more knowledge and certitude."

Hennepin and L'Homan passed through the lower lakes, but did not enter Lake Superior.

Charlevoix, whose voyage was published at Paris in 1744, passed through the great chain, and his observations are well worthy of perusal. He mentions that pieces of copper occur on the islands of Lake Superior, and that he knew a brother of the order, a goldsmith by trade, who, while on a mission at Saut Ste. Marie, had made chandeliers, crosses, and censors of it.

Shortly before the treaty of Paris, in 1763, by which the whole of this territory was ceded to the British Crown, Alexander Henry, an Englishman, visited Mackinac for the purposes of trade. At that time the Indians regarded the English as intruders, and entertained towards them hostile feelings. Henry was among the few who escaped the massacre at old Fort Mackinac, and owed the preservation of his life to the offices of a friendly Indian, who contrived to convey him to the northern shore of Michigan, whence he made his way to Saut Ste. Marie. In 1771 he superintended a mining enterprise in the vicinity of the forks of the Ontonagon river, near the site of the copper rock.

Their workings were prosecuted in the clay bluffs which line the banks of the stream, and the miners during the winter perforated the hill to the distance of forty feet. Having neglected to secure their work with supports, on the approach of spring the earth caved in and destroyed their drift. A boat-load of provisions was sent to the miners from the Saut, but, much to the surprise of Henry, when it returned on the 20th of June, he found the whole establishment of miners aboard. It is not surprising that explorations so ill-directed and visionary should prove abortive; and yet the miners represented that, in the progress of the work, they frequently met with considerable masses of native copper, and believed that they would ultimately have reached a large body of that metal.

In the month of August, 1772, the mining force was transferred to a vein on the north shore. Little was done during the winter, but before the close of autumn the miners had penetrated thirty feet into the solid rock. The vein, which at the beginning was four feet in breadth, had, in the bottom of the shaft, contracted to four inches. Under these discouraging circumstances, further mining operations were abandoned.

Henry concludes, from the results of his unsuccessful experiment in mining, that the copper can never be profitably mined, except for local consumption, and that the country must be cultivated and peopled before this can take place. He remarks, it was in the hopes of finding silver in sufficient abundance to make the speculation profitable, that the works were commenced. He speaks of the discovery of this metal in only one place, Pointe aux Iroquois, where, according to his authority, a Mr. Norburg, a Russian gentleman, acquainted with metals, discovered a blue stone of eight pounds' weight, which was sent to England and found to contain sixty per cent. of silver.

None of the early explorers seem to have noticed the existence of metallic silver associated with the copper, although we know that, among the numerous masses of copper which have been picked up on the shores of the lake, some have contained a considerable quantity of silver interspersed through them.

In 1819, General Cass, under the authority of the Secretary of War, directed an exploring expedition, which passed along the southern shore of Lake Superior, and crossed over to the Mississippi. This expedition had among its principal objects that of investigating the northwestern copper mines, and was accompanied by Mr. H. R. Schoolcraft, in the capacity of mineralogist and geologist. His observations are recorded in his "Narrative Journal of Travels from Detroit northwest, &c.," published in 1821.

In the spring of 1823, Major Long, acting under the orders of the War Department, and accompanied by several scientific gentlemen, started on an expedition, the object of which was to explore the river St. Peter's and the country situated on the northern boundary of the United States, between the Red river of Hudson's bay and Lake Superior. In returning, they coasted along the north shore of this lake. Professor Keating, in his narration of the expedition, remarks that they had seen native copper (boulders) strewed in many directions over the great valley drained by the Mississippi and its tributaries.

All the early explorers seem to agree in the opinion, that if deposites of copper should be discovered in this region, yet, so great is its distance from a market, and so wild and unsettled the character of the country, that there would be no hope of their being profitably worked—at least for many years to come.

The attention of the government was called to the mineral resources of the Northwest during the presidency of the elder Adams, and a commission was instituted with the view of exploring this region; but we have been unable to ascertain why nothing further was done in this matter.

Such was the state of things up to the time when Dr. Douglass Houghton, State geologist of Michigan, in the prosecution of his labors, commenced the exploration of the northern peninsula, and by his official reports awakened attention to this distant region. In his annual report, presented to the legislature of Michigan, February 1, 1841, the great features of the country were sketched with a masterly hand, and the first definite information with regard to the occurrence of the deposites of native copper in the rocks was laid before the world. After this preliminary reconnaissance of the country, Dr. Houghton entered into a contract with the United States government to execute the linear survey of the northern peninsula in connexion with a geological survey, according to the system devised by him in connexion with Wm. A. Burt, esq. Dr. Houghton

had, in the prosecution of the State geological survey over the extensive territory of the southern peninsula, found how great an amount of labor and how large a corps of geologists would be required, were the whole ground to be gone over by the geological parties, and had availed himself of all the information which could be obtained from the linear surveyors who had directed the United States surveys in various sections of the State. He had engaged them to notice the rocks which they should cross with their lines, and, if practicable, to procure specimens of them, so that he might thus obtain a general idea of a region which he had neither time nor means to explore fully himself. In the course of these inquiries he received a great amount of valuable information, especially from Mr. Burt; and he was thus led gradually to the idea of adopting a system which should connect the two surveys, so that they might be executed under the authority of one person, and then a systematic arrangement of a great number of observations be brought to perfection. The survey of the northern peninsula was arranged on this principle. The township lines were to be run by Mr. Burt, or under his supervision, while the subdivisions were to be made by other deputy surveyors—Dr. Houghton having the especial control of the whole. All rocks crossed by lines were to be examined, specimens taken, and the exact locality noted, while at the same time as much information as could be obtained was to be collected in relation to the geological and topographical features of the country. The detailed arrangements with regard to the collection of specimens, and the plan of accompanying the surveyors along the lines by a special barometrical observer, were admirable. This system had been fairly organized, and the field-work of one season nearly completed, when his melancholy death, by drowning, on the night of October 13, 1847, occurred. Most of the results of his extended personal observations were thus lost to the world, and the system was gradually abandoned, though for some time the linear surveyors were required to make geological observations; yet, as they were not systematized by any person familiar with the science of geology, the results were never laid before the world in an available form, although much information of value was placed in the possession of the department.

Dr. Houghton was a man of indomitable energy and perseverance, and fervently devoted to the cause of science. Had he lived to complete this great work, he would have erected an enduring monument to perpetuate his name. He died in the discharge of his duty, prematurely for the cause of science, prematurely for his own fame.

The lands composing the Lake Superior district were acquired by the United States by virtue of the following treaties:

1st. With the Ottawas and Chippewas, concluded March 28, 1836—ratified May 27, 1836—by which were ceded the lands bounded on the north by Lake Superior, on the east by the St. Mary's river, on the south by Lake Michigan, and on the west by the Escanāba and Chocolate rivers.

2d. With the Monomonees, concluded September 3, 1836—ratified February 15, 1837—by which was ceded a tract bounded on the east by the Escanāba river, on the south by Green Bay, on the west by the Monomonee river, and on the north by an irregular line extending from the mouth of the Brulé to the head-waters of the Escanāba.

3d. With the Chippewas of the Mississippi and Lake Superior, con-

cluded October 4, 1842—ratified March 23, 1843—by which was ceded the remainder of the district washed by Lake Superior on the north, and extending west from Chocolate to Montreal river, and southerly to the boundary between Wisconsin and Michigan. In this cession Isle Royale was also included.

Each of these treaties, however, embraced other lands than those described.

Shortly after this last cession, applications were made by individuals in different parts of the Union for permission to explore and locate any tracts supposed to contain valuable ores. These applications were granted by virtue of a joint resolution of Congress, passed as far back as 1818, in reference to the "lead lands" of Illinois. The applicant in the first instance was allowed to select a tract of three miles square; but this was subsequently modified, limiting him to one mile square. He was required to make the selection within one year, to mark the corners thereof, to leave a person in charge to point out the bounds, and to transmit to the proper department a description and plat of the same. On the receipt of this plat the applicant was entitled to a lease for the term of three years, renewable for an additional term of three years, provided Congress did not otherwise direct; annexed to which were certain conditions: the most important were, that the lessee should work such mines with due diligence and skill, and render to the United States six per cent. of all the ores raised—to be delivered at such points within the district as the latter might indicate.

The Committee on Public Lands of the 29th Congress, 2d session, decided that the Department of War had no authority to grant leases of *copper* mines, and recommended that these tracts be surveyed and sold.

On the 6th of May, 1846, in conformity with the decision of the President of the United States, the further issue of permits was suspended.

The whole number of permits granted under the authority of the Department of War amounted to about one thousand—nine hundred and sixty-one of which were located. Sixty leases for tracts of three miles square, and three hundred and seventeen for tracts of one mile square, were perfected, and mining companies organized under them.*

At the subsequent session of Congress an act was passed, entitled "An act to establish a new land district, and to provide for the sale of mineral lands in the State of Michigan," approved March 1, 1847.

By the first section of this act, all of that portion of the public lands in the State of Michigan lying north of the boundaries of the Saginaw and Grand river land districts in the State, known as the northern peninsula, with the islands in Lakes Superior, Huron, and Michigan, and in Green bay, the Straits of Michillimackinac, and the river St. Mary's, within the jurisdiction of said State, was included in one land district, to be called the Lake Superior land district.

The second section provides that the Secretary of the Treasury cause a geological examination and survey to be made and reported to the Commissioner of the General Land Office; that the President be authorized to cause such of said lands as may contain copper, lead, or other valuable ores to be exposed to sale, first giving six months' notice of the times and places of such sale in such newspapers of general circulation in the several

* Report of D. R. McNair, Mineral Agent; Ex. Doc. No. 2, 30th Congress, 2d session.

States as he may deem expedient, with a brief description of the lands to be offered—showing the number and locality of the mines known, the practicability of discovering others, the quality of the ores, the facilities for working the mines, and the means and expense of transporting their products to the principal markets of the United States; and that all of the lands in the said district not reported as mineral be regarded as agricultural.

The third section secures the rights of those persons in possession by occupancy under permits, or leases, from the Secretary of War. The other sections of the act in no way relate to the objects of the survey, and a recital of their provisions is omitted.

From the time of the issuing of the permits the business of mining has been prosecuted with vigor, and in many instances with success. The day is not distant when the product of these mines will supply the home demand, and add much to the national wealth. In a business like this, proverbially uncertain the world over, there have been many failures, many schemes of wild and extravagant speculation, and many plans of ill-advised and ill-directed mining, which have resulted in the ruin of those engaged in them. Extravagant expectations were held out in the commencement, which the mining experience of the world declared could never be realized.

These, however, have passed away, and the business has settled down into a regular, methodical pursuit, affording an admirable field to the mining engineer for the display of skill and judgment, and yielding to the adventurers a reasonable return for the capital invested.

In the spring of 1847, pursuant to the provisions of the above-recited act, the Secretary of the Treasury appointed Dr. Charles T. Jackson to execute the required survey. After having spent two seasons in the prosecution of this work he resigned, and its completion was confided to Messrs. J. W. Foster and J. D. Whitney, the results of whose observations will be found embodied in the subjoined report.

In the prosecution of this work they have been aided by Messrs. S. W. Hill and Edward Desor, as first assistants, by Mr. William Schlatter as draughtsman, and Mr. W. D. Whitney as botanist.

The aid of Mr. Hill has been of the most essential service. His long residence in the district and his connexion with several public surveys in the Northwest, had given him opportunities of collecting a large fund of information, which has been cheerfully contributed to this work. His measurements and plans of the mines, his observations on the phenomena of veins, his contributions to the boundaries of the rocks, as illustrated on the accompanying maps, and his thorough and laborious explorations during his connexion with the survey, are all gratefully acknowledged by the geologists in charge.

The phenomena of the *drift* and alluvial deposites of this region have been ably investigated by Mr. Desor, and the results of his observations will be found embodied, by him, in that portion of the work which relates to the superficial and transported materials.

His previous investigations of the drift in parallel latitudes in western Europe, and of glacial action as manifested in the Swiss Alps, and the formation of shoals along the coast of the Atlantic as observed by him during his connexion with the Coast Survey, had qualified him to enter upon this field with every prospect of success.

When it is considered that the agricultural capacity of a soil results not so much from the decomposition of the subjacent rocks as from the superficial deposites strewn over the surface, which have been derived in most cases from sources far remote, it will be found that an undue prominence has not been given to this subject. Besides, an investigation into the sources of these materials, and the agency by which their transport has been effected, forms one of the most interesting chapters in the physical history of the earth.

The results of his observations on the *fauna* of this region will be communicated hereafter.

The execution of the maps was confided to Mr. William Schlatter, and we do not pay him an underserved compliment when we say that he has completed the work with consummate skill and ability. Much of this work has been executed in the midst of the forest, beneath the shelter of a tent.

The investigations of Mr. W. D. Whitney were mainly directed to the *flora* of this region. His remarks on the nature of the forest trees, their geographical distribution and the economical uses to which they may be applied, will be incorporated in a subsequent report.

Before concluding this introduction we desire to return our thanks to the several captains of mines for their hospitality and for the facilities afforded us in investigating the phenomena of veins. Without exception, we have found them intelligent and ready to communicate all of the information in their possession.

To the linear surveyors, particularly to Mr. John Burt, we desire to render our thanks for the communication of valuable information.

To the late surveyor general, Hon. Lucius Lyon, of Detroit, we also desire, in a public manner, to express our thanks for his promptness in furnishing plats, and for other aid rendered in the prosecution of this work.

We are fully aware that this report is, in many respects, defective; such as must necessarily result from the investigation of a wild and almost unbroken wilderness, with limited facilities at our disposal. We trust, however, that we have accomplished something in elucidating its true geological structure and its vast mineral resources.

CHAPTER I.

PHYSICAL GEOGRAPHY.

Boundaries of the Lake Superior land district.—Extent of the lake.—Islands.—Harbors.—Bays.—Coast.—Michigan.—Extent.—Bays.—Islands.—Huron.—Rivers.—Mountains.—Table of heights.

The region which forms the immediate subject of this report is bounded on the north by Lake Superior, on the east by the St. Mary's river, on the south by Lakes Huron and Michigan, and on the west by the Montreal and Menomonee rivers, including the several islands belonging to the United States, and within the jurisdiction of Michigan. It is known as the *Lake Superior land district,* and contains an area of 16,237 square miles.

It is included between latitude 45° and 49° north; and longitnde 83° 45′ and 90° 33′ west from Greenwich. Its coast, more than 800 miles in extent, is washed by three of the great North American lakes.

Lake Superior, the largest expanse of fresh water on the globe, contains 32,000 square miles. Its surface is elevated, according to Captain Bayfield, of the English Admiralty survey, 627 feet above the ocean-level, while portions of its bed are several hundred feet below; thus forming one of the deepest depressions in the surface of the earth, excluding those portions covered by the oceanic waters. Its coast is 1,500 miles in extent: its maximum length, from Gros Cap to Fond-du-Lac, in a direct line, is 355 miles; its maximum breadth, from Grand island to Neepigon bay, 160 miles.

The shape of the lake is very irregular, its widest expansion being near the centre, while its extremes are contracted. Its northern shore is rocky, affording many bold headlands, and many deep and spacious bays. Numerous groups of islets gird the coast, which appear to be peaks, or aiguilles, connecting with the main rock far below.

Of the larger class may be mentioned St. Ignace, at the outlet of Neepigon bay, 1,300 feet in height; and Pie island, at the outlet of Thunder bay, which rises to the height of 850 feet. They are both composed, in the main, of rocks of igneous origin, and present bold and picturesque outlines.

The southern coast is studded with fewer clusters. Towards the head of the lake there is a group known as the Apostle islands, composed of sandstone, and attaining an inconsiderable elevation. The channels between them afford good harbors, accessible from every point. La Pointe, situated on Madaline island, is already a place of some commerce.

Grand island, about midway between the extremes of the lake, affords one of the finest and most beautiful harbors in the world. Its northern shore, where exposed to the surf, is lined with high cliffs of sandstone; but the southern portion slopes gradually to the water's edge.

Towards the eastern extremity are several low islands, composed of sandstone, which are of no great importance.

In addition to these are two remarkable islands in the midst of the

lake, both of which are due to volcanic action. These are Isle Royale and Michipicoten; the former belonging to the United States, the latter to Great Britain.

Isle Royale is situated in the northwestern part of the lake, being intersected near the centre by the 89th degree of west longitude, and the 48th of north latitude. Its course is northeast and southwest; its length about forty-five miles; its width about eight miles; its area two hundred and thirty square miles.

It is traversed by numerous parallel ridges, running with the course of the island, which nowhere attain an altitude of more than 600 feet above the lake-level. At the northeast extremity they are prolonged beyond the main land, and resemble the fingers attached to the human hand. These fingers afford safe and commodious harbors. The numerous long and narrow inlets which indent the coast result from its geological structure. Alternating bands of soft amygdaloid and hard crystalline greenstone, which oppose unequal resistance to the action of the elements, have contributed to form the peculiar outline of the coast. Powerful currents, at no remote epoch, swept over the island in a southwesterly direction, which ground down the softer beds and polished and grooved the harder, to their very summits. So thorough was this process, and so slightly have the harder materials, in the lapse of time, yielded to the ordinary action of the elements, that these grooves can be observed over surfaces of great extent, sharp and well-defined. No tree takes root upon these polished surfaces; the lichens even cannot find sustenance. The island everywhere presents a desolate appearance. Barren rocks; a dwarfed growth of cedars and birches, hung with drooping moss; abrupt cliffs, impassable marshes—these are the striking characteristics. The caribou, the lynx, and the rabbit are among the few animals that roam over its surface; the hawk, the owl, and the pigeon represent the feathered tribe.

Where the igneous rocks prevail we find deep and spacious inlets, among which may be mentioned Washington harbor on the west, Todd's harbor and McCargoe's cove on the north, the deep recesses formed by Locke's point, Blake's point, and Scovill's point, on the east, and Rock harbor, Chippewa harbor, and Siskawit bay on the south. The southern point of the latter bay, which consists of sandstone, is approachable from the southeast, and also from the south, by a narrow and intricate channel. It abounds in hidden reefs, running parallel with the main land.

The numerous ridges which traverse the island longitudinally are uniformly bare and precipitous on the northwest and sloping on the southeast. The intervals are occupied by small lakes, wet prairies, or cedar swamps.

Michipicoten is situated in the northeastern portion of the lake. It is eighteen miles in length, and rises to the height of eight hundred feet above the water. It is a mass of greenstone, and one of the points selected by the Quebec Company for mining operations.

In the midst of the lake is a remarkable islet, known as Stannard's rock, so called in honor of Captain Charles C. Stannard, by whom it was discovered in 1844, while sailing the brig Astor.

It has been erroneously described as an isolated peak or needle, shooting up from the bottom of the lake, and affording deep soundings on every side. Such, however, is not the case. It rises about four feet above the water-level, and exposes a surface of fifty feet in length and twenty in breadth. During a storm the waves sweep over it, but its posi-

tion is indicated by a long line of breakers. Professor Mather, who visited it in 1846, thus describes it in some MS. notes communicated to us: "A dangerous shoal extends a mile or more to the NNE. of the rock, and another, as indicated by the ripple, to the NNW. In approaching it, we passed over numerous ridges and deep troughs between—the rocky bottom plainly in view from ten to fifteen and twenty feet below the surface." To the south and southwest of the rock the water is deep, even at its base. It is a sandstone of a dark red color, and somewhat metamorphosed by heat, and disposed in nearly horizontal layers. Its bearings, from the most reliable information, are, from Manitou island, at the head of Keweenaw Point, SE. ½ E. 27 miles; from Point Abbaye, E. by N. ½ N. It lies in the direct route between Grand Island and Keweenaw Point, so that it is necessary for the navigator to make a detour to avoid it.

This is the only reef known to exist in the midst of Lake Superior, and it is a matter of surprise that it remained so long undiscovered.

Professor Mather states that at the time of his visit a strong current was setting eastward, which drifted the vessel more than half a mile from her course. The lake was calm and the breeze light; the approach to the rock, therefore, is dangerous even under the most favorable circumstances.

The northern shore is much more deeply indented than the southern. Among the deepest of these indentations may be mentioned Neepigon, Black and Thunder bays, which, for the most part, are lined with elevated ridges extending down to the water's edge. No place in the northwest presents a view of greater magnificence than is afforded in the vicinity of Fort William. Blackened walls of slate and trap, covered with a dwarfish growth of cedar and birch, are seen on every side. To the south Pie island rises out of the lake, like an immense castle, to the height of 850 feet: to the west, McKay's mountain, a thousand feet in height, overhangs the valley of the Kaministiquia, its flanks composed of basaltic columns as regular as those of Staffa: to the east, Thunder cape, 1,350 feet in height, with unbroken cliffs extending for seven miles, resembling a vast colonnade, juts into the lake, beyond which the eye rests upon a dark expanse of water bounded only by the horizon, while to the north serried ranges of mountains rise one above the other until their outlines are dimly traced against the sky.

The general trend of the southern coast is east and west, to which, however, Keweenaw Point forms a remarkable exception. Starting from its base, it projects for fifty miles into the lake, taking a northeasterly direction; then curving inwardly, it pursues for twenty miles an easterly course, terminating in an abrupt headland which rises to the height of 800 feet above the lake. This configuration is due to a range of trappean hills, which in their widest expansion do not exceed twelve miles, or attain an elevation greater than 900 feet above the lake.

The southern coast is less rock-bound and irregular than the northern. The principal indentations are Chaquamegon bay, Keeweenaw and Huron bays. This difference in the character of the two coasts results from the diversity in their geological structure.

Where the rocks consist of different degrees of hardness the coast presents numerous inlets, bays, and harbors, with deep but narrow channels; but where the rocks are of nearly uniform consistency, the shores are gently curved, the bays wide, and the harbors sparse. Thus it will be seen, by inspecting the geological map, that where the igneous rocks pre-

vail, the coast is finely indented; where the sandstones prevail, the coast is gently curved. Copper harbor, Agate harbor, and Eagle harbor are excavated in a belt of amygdaloid, included between two belts of conglomerate, which offer greater resistance to the action of the sea and the atmosphere. A stream or a fissure may have served originally as an inlet to the waters, whose excavatory power was circumscribed by the harder and firmer sedimentary rocks.

Between Eagle harbor and the Montreal river the coast, composed of sandstone, presents no projecting headlands, no sheltered bays. To the east of Keeweenaw bay there are several bold projections which result from the joining of rocks of unequal resisting power. The heads of the promontories generally consist of granite or basalt, connected with the main land by low and narrow spits of sandstone. Granite Point and Presqu'Isle are examples of this kind. Within the present century the connecting link may be severed, and the promontories become insulated like the Huron islands, which at no remote epoch were undoubtedly connected in a similar manner with the main land.

Lake Superior occupies an immense depression, which has been for the most part excavated out of the soft and yielding sandstone. Its configuration on the east and north has been determined by the irregular belt of granite before noticed, which forms a rim effectually resisting the further encroachments of its waters. Limited patches of sandstone, such as Caribou, Parisien, and Maple islands, have escaped the process of demolition, and indicate the ancient limits of the detrital rocks.

The configuration of that portion of the lake lying west of longitude 88° appears to have been caused by two axes of elevation exteuding in parallel lines from the northeast to the southwest, which upraised the sandstone, causing it to form a synclinal valley. Another valley of a like character occurs south of the trap range of Keweenaw Point and the Ontonagon region, in which the water has excavated a deep and spacious bay; but its encroachments are limited in that direction by the granite bosses of the Huron mountains. Let any one who doubts that the configuration of the lake results from geological causes consult the map of this region, and he will be satisfied that all the projections and indentations of the coast conform in a remarkable degree to the main lines of upheaval.

The southern coast of this district is washed by the waters of Lakes Huron and Michigan. The superficial area of the latter is nearly a third less than that of Superior, being twenty-two thousand square miles, while in depth it is not much inferior. It is elevated five hundred and seventy-eight feet above tide-water, and depressed forty-nine feet below Lake Superior. The rocks which compose its rim are of a sedimentary nature, and afford few indentations suitable for harbors. The immediate shores are low, and lined in places with immense sand-banks. The water shoals gradually in approaching the coast. Green Bay in other countries would be regarded as a lake of great magnitude—its length being one hundred miles, its average breadth twenty. Great and Little Traverse bays occur in the eastern coast, and Great and Little bays d'Enoch in the northern. The maximum length of the lake is three hundred and twenty miles, its maximum width one hundred, and its circumference somewhat less than one thousand miles. Its form is oblong, with much uniformity in its outlines. The islands are sparsely distributed, and

attain an inconsiderable height. Two clusters occur—one at the outlet of the main lake, the other at that of Green Bay.

Lake Michigan is connected with Lake Huron by the Straits of Mackinac, forty miles in length, and four in breadth. At the narrowest point within this strait there are two considerable islands—Bois Blanc and Mackinac. The former is a low, wooded island, twenty-five miles in circumference.

Mackinac is only about three miles in diameter, and rises to the height of three hundred and fifteen feet; it is walled on every side by bare cliffs of limestone, which afford many scenes of picturesque beauty. As a military post, it may be considered as the Gibraltar of the lakes. Formerly it was one of the principal depots of the American Fur Company; but of late years the traffic has rapidly declined. The commanding position of Mackinac did not escape the keen eye of the Jesuits. Dablon speaks of it, in 1670, as the centre of three great lakes; and from that day to the present it has been an important point—a sort of council ground—in the negotiations between the two races. The harbor is excellent. There is nothing to make this island a place of any great commercial importance; but had the government relinquished the fee of the lands, it would have presented a far different appearance from what we now behold. Michimackinac signifies big turtle, so called from a fancied resemblance in the contours of the island to the form of that animal.

Lake Huron is little inferior in dimensions to Michigan, its greatest length being two hundred and sixty miles; its greatest breadth one hundred and sixty. Its circumference is eleven hundred miles; its area twenty thousand four hundred. Its shape is that of an inverted cone. Georgian bay, one hundred and seventy miles in length and seventy in breadth, forms the northeastern portion, and lies exclusively within the British jurisdiction. Saginaw, a deep and wide-mouthed bay on the western coast, is the principal indentation. The rim of the lake is composed for the most part of detrital rocks, which are rarely exposed. In the northern portion of the lake, however, the trap rocks on the Canada side intersect the coast. The waters possess great transparency, and extend to a depth not surpassed by those of Superior and Michigan. They rarely attain a temperature higher than 50°, and are stocked with fish of the finest flavor. The surface exhibits the dark-blue, or blue-black, so characteristic of the ocean.

The northern coast, in the vicinity of the outlet of the St. Mary's, abounds in numerous clusters of islands, which form the most attractive feature in the landscape. Captain Bayfield is said to have landed on ten thousand, in the prosecution of his survey, and to have estimated the whole number at thirty thousand.

The following table, with some alterations, exhibiting the area, elevation above the sea, and depth of the five great lakes, is taken from the report of S. W. Higgins on the topography of Michigan:

Lakes.	Greatest length.	Greatest breadth.	Mean depth.	Height above sea.	Area in square miles.
	Miles.	*Miles.*	*Feet.*	*Feet.*	
Superior............	355	160	900	627	32,000
Michigan..........	320	100	900	578	22,000
Huron..............	260	160	900	578	20,400
Erie................	240	80	84	565	9,600
Ontario............	180	35	500	232	6,300
Total........	....	....	....	....	90,300

The entire area drained by these lakes is estimated, on the same authority, at 335,515 square miles.

This district is a part of that immense plain bounded by the Appalachian chain on the east, and the Rocky mountains on the west, and extending north and south from the Gulf of Mexico to the Arctic sea. Its mean elevation above the sea is less than a thousand feet, and its culminating points nowhere exceed 2,500 feet. They can hardly be dignified with the name of mountain chains, but may be regarded as the more elevated portions of a gently rising and widely extended plateau.

The beds of the great lakes are depressions, reaching far below the ocean level.

In this plain, with their branches interlocking, the two great rivers of North America have their origin—the Mississippi and St. Lawrence; the one discharging its waters, through many mouths, into the Gulf of Mexico; the other expanding into a gulf many hundreds of miles in extent before it becomes merged in the ocean.

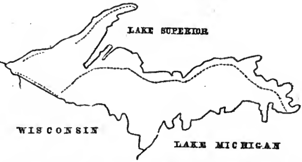
These rivers are as diverse in character as in direction. The Mississippi is the longer, but the St. Lawrence discharges the greater volume of water. The one abounds in difficult rapids, the other in stupendous cataracts—the one is subject to great fluctuations, the other preserves an almost unvarying level. The waters of the one are turbid; those of the other possess an almost crystal purity. The one affords few lake-like expansions; the other swells into vast inland seas. Both have become the great highways of commerce, enriching the regions through which they flow, and supplying the inhabitants with the varied products of distant climes.

Lake Superior is fed by more than 80 streams, none of which attain any considerable magnitude, and are adapted only to canoe navigation. Those which flow down the northern slope of the basin are longer than those of the southern, and the water, being more exposed to the direct rays of the sun, possesses a higher temperature. They all have rapid descents, and, flowing over rocks which oppose great resistance to the action of water, abound in falls and rapids. The carrying-places around these obstructions are known as "portages." Communication throughout the northwest between distant points is effected almost entirely with the canoe. It serves the same purpose as the ship on the ocean, or the camel on the desert. This kind of inland navigation has created a class of men of marked peculiarities, known as voyageurs. They are a hardy race, pa-

tient of toil, and cheerful under the most untoward circumstances. In their frail barks they pass from Lake Superior to the Mississippi, to Hudson's bay, to the Pacific, and even to the Arctic ocean.

Rivers.—Rivers are the great arterial features of our globe; they define the valleys, give boundaries to the hills and mountain ranges, and if traced to their source, enable us, with the aid of a few well determined culminating points of contiguous ranges, to trace upon our charts the general feature of the country through which they flow.* This knowledge is particularly desirable at this day, when rapid communication is sought between distant points by means of railways. By barometrical observations extended over most of the district the elevation of the water-shed line has been determined. These will aid in the selection of the most practicable route between the two lakes, and enable the observer to form a pretty correct idea of the physical features of the region.

The following diagram shows the course of the water-shed in this district. It is represented by the irregular dotted lines:



It will be seen that the streams flowing into Lake Michigan, in the eastern portion of the district, head near Lake Superior. Proceeding west, the line is deflected from the upper lake, and another line diverges towards the northeast. The main line is due to the upheaval of the granite; the secondary line to that of the trap.

We will describe the rivers of this region in their order of succession, rather than with reference to their magnitude.

The Montreal is a river of no great magnitude, being navigable above the falls at its mouth by canoes only during the time of flood. It is formed by the union of the Pine and Balsam rivers, thirty-four miles above its mouth, following its meanders. At this point, according to Captain Cram, it is eight hundred and four feet above Lake Superior. Flowing over hard unyielding rocks, it abounds in numerous rapids and cataracts. Near its mouth it is precipitated eighty feet over a sandstone ledge. Four miles up, there is another fall of about the same height, but much more picturesque. The aboriginal name of this stream is *Ka-wasiji-wang-sepi*, or White Falls river.

The *Black* and *Presqu'Isle* are streams of considerable magnitude, which have their sources in the granite near the southern limits of the

* Captain F. W. Beechey, R. N.—Manual of Scientific Inquiry, art. "Hydrography."

district. They flow northwesterly, and, breaking through the trap range, discharge themselves into Lake Superior.

The *Ontonagon*—or *Nantonagan*, according to the orthography of the Jesuit map—is the largest of all of the streams within this district which flow into Lake Superior. It has three principal affluents which combined, drain an area of not less than thirteen hundred square miles. Their sources are found near the southern limits of the district, interlocking with those of the Chippewa and Menomonee. One of the affluents of the west branch drains a large inland lake, known as Agogebic or Little Fish lake, which lies about seven hundred feet above the main lake. The waters are clear, cold, and deep, and swarm with fish of the finest flavor. After leaving this lake, the course of the stream is northeast along the junction of the sandstone and trap, until it unites with the main river, and has, in places, excavated a channel in the sandstone to the depth of one hundred feet. After this junction the combined stream turns abruptly to the north, flowing across the trap range in a natural depression, through which it finds its way to the lake. The southern and eastern branches, for a greater portion of their courses, flow through a country deeply covered with stratified clays, and their channels are excavated in the yielding beds. The banks in places rise to the height of one hundred and fifty feet, and are so precipitous that it is a task of great labor to clamber to their tops. The depth of water in each of these branches is sufficient to float a canoe, but numerous portages occur in consequence of the great accumulation of drift-wood. Some of these "rafts" are fifteen rods in extent.

At the mouth of the Ontonagon there is a sand-bar, on which there is ordinarily from five to six feet of water. During the spring-flood this bar is often washed away, but it is reformed by the northerly winds, which drive in a heavy sea. The extension of piers from this point for the distance of four hundred feet seaward, so as to confine the current within a narrow compass, would remove this obstruction and render the entrance at all times accessible. The bar once passed, there is a spacious harbor two hundred and fifty feet in width and eight miles long, with a depth of water between twelve and fifteen feet. The mouth of the river has already become a place of much importance, and an improvement of this kind would be of great value to this portion of the mining region, although its construction would be a work of much labor and expense. The nearest points where vessels can take refuge in a storm are La Pointe and Eagle Harbor, each of which is about seventy-five miles removed.

A keel-boat seventy-five feet in length, and capable of carrying ten tons, plies between the mouth of the river and the Minnesota landing, distant fifteen miles. Three miles below this point occur the Grand rapids, which present a very serious obstruction to the navigation. These, however, have been so far improved by removing the boulders from the channel, that boats can ascend by poling or warping.

Between Keweenaw Point and the Ontonagon there are several small streams, which have their origin in the trap range and flow northward into Lake Superior. Their descent is rapid, and they afford an abundant supply of hydraulic power. Two inconsiderable streams occur near the head of Keweenaw Point, Eagle and Montreal rivers. The former flows along a longitudinal valley for a distance of six miles, then breaks through the trap range at nearly right-angles with its former course, and is precipitated

into the lake. It is the only stream of any magnitude in the vicinity of the mines on the Point, and its waters have been already employed in the washing of the ores.

The *Little Montreal* flows through a longitudinal valley between two ranges of trap, and enters the lake a little below the eastern extremity of the point.

The *Sturgeon*, with the exception of the Ontonagon, is the largest river on the northern slope of the axis between Lakes Superior and Michigan, and its sources are elevated more than a thousand feet above its outlet. The area drained by its tributaries is five hundred and seventy-five square miles. For the first twenty miles its course lies through the granite and metamorphic rocks, and the descent is rapid; after that it enters a broad and slightly undulating plain deeply covered with transported materials, and discharges itself into Portage lake. Its entire length, including its sinuosities, is not less than sixty-five miles. For the last fifteen miles of its course, it runs parallel with Keweenaw bay. Between its mouth and township 51, range 34, its course is very tortuous. Its banks are composed of clay, with pebbles intermixed, and rise from six to eight feet above its surface. Its width at this point is about one hundred and forty feet, its depth about four feet, and a luxuriant growth of forest trees, consisting of elm, maple, linden, and black ash, lines its banks.

After crossing the correction line the country changes in its character. The ravines are numerous and deep, and the ridges of sand and clay attain a higher altitude. A change is also observable in the forest trees, the cedar, fir, and white birch supplanting the elm, the maple, and the ash.

One of our party, Mr. Hill, ascended this river in a canoe for a distance of twenty-five miles. His progress was occasionally obstructed by driftwood, around which he was compelled to make portages. The lower portion of this valley may be regarded as among the best agricultural tracts in the northern peninsula. The Sturgeon has, in the course of ages, formed a delta at its mouth about four miles in extent. It contains many lagoons, which at one time formed the bed of the river. This bottom annually yields a luxuriant crop of blue-grass, which is mowed and conveyed to L'Anse.*

Portage lake, which may be regarded as an expansion of Sturgeon river, lies in the form of a rhomb at the base of Keweenaw Point. It is about eighteen miles in circumference, and has three principal arms—one connecting with Keweenaw bay, another with Torch lake, while the third extends to within a mile of Lake Superior, on the northwest side of the Point, across which there has been a portage from time immemorial.†

* L'Anse properly signifies "the bay, or creek," but throughout this region it is applied to designate the settlements at the head of Keweenaw bay. These consist of a Catholic mission on the west side, and a Methodist mission on the east. There are about four hundred souls, consisting of Indians, half-breeds, and whites; the first largely predominating. Their pursuits consist in fishing and hunting; cultivating, however, patches of potatoes, for the growth of which the soil is admirably adapted. At each mission there is a school. The government employs a blacksmith, a carpenter, and a farmer, whose duties are to aid and instruct the Indians in their respective arts. There are also three or four traders who furnish the Indians with goods, in exchange for fish and peltries. At the head of the bay is a saw-mill owned by Mr. Boswell, which annually turns out twenty thousand feet of lumber, worth from ten to thirteen dollars per thousand at the mill.

† Father René Mesnard was lost while crossing this portage, on the 20th of August, 1661. It is strange that no headland, or lake, or bay, throughout this vast region, bears the honored name of him who was the first white man to explore them.

By pursuing this route between La Pointe and L'Anse, the distance is shortened about eighty miles. The river connecting Portage lake with Keweenaw bay is about four miles in length, being broad and deep. The water on the bar at the mouth, however, is but about four feet deep.

Between Keweenaw bay and White-Fish point there are no large rivers. The principal streams are the *Huron*, *Dead*, (Du Mort,) *Carp*, *Chocolate*, *La Prairie*, and *Two-Hearted*. They have their sources near the lake, and descend rapidly, affording abundant water-power. They are not navigable for canoes even, except for short distances, but their mouths, for the most part, afford tolerable boat harbors.

The *Tequamenen* is among the largest streams on the northern slope. Its length is sixty-five miles, and the area drained by it not less than six hundred square miles, and its course is nearly parallel with that of the lake coast. It can be ascended to the foot of the falls fifteen miles up, in coasting boats, and still further in canoes by making portages around the obstructions.

Passing to the southern slope of the axis, the *Manistee* is the principal river in the eastern portion of the district. It drains a flat, swampy country, about 1,300 square miles in extent. It has four principal affluents which come in from the northwest, some of whose branches head within five miles of the Lake Superior coast. Over this area are scattered numerous lakes which serve as reservoirs to collect and retain the superfluous water.

The White-Fish, Escanāba, and Fort rivers flow into Little Bay d'Enoch. Each drains an area varying between 400 and 500 square miles, and all may be ranked among the second class rivers of this region. Their banks are covered with pine forests, and large quantities of lumber are annually shipped to Chicago and other ports.

The *Menomonee*, which forms in part the boundary between Michigan and Wisconsin, is the largest river within this district with the exception of the St. Mary's. Some of its sources lie within fifteen miles of Lake Superior—its outlet is two hundred miles distant. Its eastern branch, called the Machigamig, or river flowing from a big lake, rises in the Huron mountains, which are 1,249 feet above Green bay. After crossing the summit level in township 48 north, range 32 west, there are a series of natural meadows covered with grass, through which flows a small, clear stream, across which one may leap with ease. After pursuing this for about three miles, we come to where it discharges itself into a small lake called by the Indians, *Sagiagāns*. This is the head of canoe navigation between Keweenaw bay and Green bay of Lake Michigan,* and lies 1,049 feet above that lake. There are two other lakes in close proximity, connected together by tortuous streams. A sharp range of granite hills bounds them on the north, while to the south the country is level and marshy. Between the second and third lakes occurs Portage No. 1, three-fourths of a mile in extent, and on the right bank of the stream.

*In the fall of 1848 we passed over this route to Green Bay. Our canoe was borne by two voyageurs from L'Anse to this point, distant twenty-five miles, over elevations 1,200 feet above the lake, through cedar swamps where for miles we had to hew our way, and wade through meadows knee-deep in water. It was a herculean feat of strength and endurance, accomplished in little more than two days, and Agindos, whose shoulders bore the bulk of the burden, deserves to be particularly named. As this route is practicable, but never travelled except by Indians, we will describe it with some minuteness.

The descent is twenty-four feet—the channel being filled with numerous boulders. Portage No. 2 is on the left bank of the stream, a short distance above the point where it discharges itself into the Machi-gummi, or Big lake, (section 25, township 48 north, range 31 west.) The Portage is three-fourths of a mile long—the descent twenty-nine feet.

Machi-gummi lies 1,014 feet above Lake Superior. It occupies the entire length of township 48, range 30, and in its southern prolongation extends into the adjoining township. On the north it is bordered by a range of hills rising in conical knobs to the height of two hundred feet: on the south, the country is less elevated. Its surface is dotted with numerous small islands rising up dome-shaped, with much regularity of outline. These summits are clothed with a dwarfish growth of cedar and fir, while their sides exhibit blackened masses of hornblende.

This lake is seldom visited by the white man, but the Indians resort here to hunt and trap. Along its shores are valuable deposites of iron, and its solitude may be disturbed within the present century by the sound of the forge-hammer and the puff of the steam-engine.

At the outlet of this lake the stream becomes augmented to the width of sixty feet, with an average depth of two feet; and the descent is very rapid: the water is highly colored, and flows over a gravel bed.

About a mile below the outlet occurs the third portage, on the left bank of the stream. It is a mile in length; the descent 35 feet. The bed of the stream is filled with boulders of hornblende and granite. Portage No. 4 occurs in section 7, township 46, range 29, on the left bank. Length half a mile, descent 14 feet.

Between these two portages the river is confined within narrow alluvial banks, but it occasionally enlarges into lake-like expansions which are fringed with tall grasses. These become the resort of innumerable water-fowl, while the wooded banks are the chosen haunts of the beaver and otter. Pealed sticks of yellow birch, often seen floating in the stream, indicate the proximity of the former, while numerous "slides" in the plastic clay-banks show that we were in the neighborhood of the latter.

This portion of the country, though elevated, contains few ridges. The rocks rarely emerge to the surface, but are concealed by heavy accumulations of sand, clay, and gravel, mingled together pelé-mêlé. The stream descends rapidly, and its channel is filled with large blocks of hornblende and granite.

Near the north part of township 46, ranges 29 and 30, a ridge rising two hundred feet above the surrounding level is seen, ranging north of west. Towards the river it presents a nearly unbroken cliff one hundred and thirteen feet in height, which, on examination, proved to be nearly pure specular oxide of iron.

Portage No. 5 is on the right bank of the river, in township 45, range 29; length two and a half miles. The river for a long distance above presents a series of rapids, many of which are difficult and dangerous.*

* We have indicated on the general map the position of the rapids; and in this report we have described their character with some minuteness. We have done this for the benefit of future navigators. When one arrives at the head of a rapid white with foam and dotted with projecting rocks, he is desirous of knowing beforehand whether the descent be practicable; for once within the current, there is no power to retrace.

We have often had occasion to admire the dexterity displayed by our Indian voyageurs in descending long and difficult rapids. It requires a quick eye instantly to detect the deepest part of the channel, and to determine, by the break of the water, the position of hidden rocks—a

The descent between the foot of Portage No. 4 and the head of Portage No. 5 is eighty-seven feet; the descent of Portage No. 5 is thirty-seven feet.

Portage No. 6 is on the line of sections 29 and 30, township 44, range 29; length one-eighth of a mile. It is caused by an accumulation of flood-wood, so thickly matted that bushes and flowers have taken root, and flourish luxuriantly. Here the winter trail to Green Bay passes, and the mail courier has availed himself of this obstruction to cross the river.

Within this township the Machigamig receives from the right its two principal tributaries, the Mitchikau or Fence river, and the Nebegomiwini or Night-watching river. The origin of these terms, as explained by our voyageurs, was this: At one time the deer were observed to be very numerous about the mouth of the former river, and the Indians, to secure them, built a fence from one stream to the other. They would follow rather than overleap this barrier, until they were entrapped by their concealed foe. This method of capturing the deer is also practised on the Menomonee.

The latter stream abounds in beaver and other game; and it is the practice of the Indians, in the clear moon-light nights, to watch on its banks for their appearance; hence the origin of the term.

Portage No. 7 is about two miles below the mouth of the last-named river, (township 43, range 31.) It occurs on the right bank, and is only one-quarter of a mile in length. The river here falls perpendicularly nine feet. A high range of slate rocks, rising from the immediate banks one hundred and fifty feet, was observed.

Portage No. 8 (township 48, range 31) is over a ridge of hornblende and feldspar rocks, through which the river has excavated a channel: length one-eighth of a mile, descent seventeen feet.

Portage No. 9 is in the same township and range, about four miles below the former, on the left bank of the river; it is one mile and three-quarters long, the descent being forty-two and a half feet. The ridge, bearing north 72° east, attains an elevation of one hundred and fifty feet, whose summit is composed of granite, but the flanks consist of hornblende and mica slate, folded over it like a mantle. The banks of the stream are lined with precipitous ledges, and, altogether, it forms one of the most beautiful and romantic gorges on the Machigamig. The country in this vicinity is traversed by numerous ridges, more or less broken, which nowhere attain a great elevation. The rocks emerge to the surface at short intervals, and the immense accumulations of drift noticed above are wanting.

Portage No. 10 is in the north part of township 42, range 31, about a mile and a half below the latter, on the left bank of the stream: length one mile and an eighth. The current is rapid both above and below, the descent between the two being fifty-six feet. At the foot of the rapids are several small islands which divide the current.

The last portage (No. 11) is about one-quarter of a mile above its junction with the Menomonee. It is on the right bank of the stream, and one-eighth of a mile in length. The river here breaks through a ridge of

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vigorous hand to guide the frail canoe as it dashes on its tortuous course with the speed of a race-horse. Accidents often occur, but fortunately the means of refitting are always at hand—to wit, birch bark and spruce gum.

hornblende slate, over which it is precipitated twenty-four feet. It is the most romantic of all the cascades on the Machigamig.

The length of this stream from Sagiagans, following its meanders, is about seventy miles, and its general course is south of west: the area drained by it is nearly eight hundred square miles. The Brulé, or Wesacota, here joins it on the right, and, after the junction, the united streams take the name of the Menomonee.

The Brulé has its origin in a lake of the same name, through which passes the south line of the boundary of this district. It is one of a chain of beautiful lakes which extends almost uninterruptedly along the whole southern border. The current is rapid; but only two portages occur in its course, about ten miles above its mouth, near the junction of the Mequacumecum, in township 41, range 32. The stream is eighty or ninety feet in width, its bed rocky, and its banks studded with a thick growth of cedar, tamarack, and birch, whose overhanging branches often obstruct the passage of a canoe. The Indians have been accustomed to ascend this river from time immemorial, on their route from Green Bay to Vieux Desert, and numerous camping-grounds are to be found along its banks. Its ascent is at all times practicable in a light canoe. The Mequacumecum is its principal affluent, which rises near the sources of the Sturgeon It has as long a course, and drains as great an area, as the Brulé itself. This river, too, is frequently ascended by the Indians in their passage to Lake Superior. The length of the Brulé is about fifty miles. The area drained by the Brulé and Mequacumecum contains about nine hundred square miles.

The *Menomonee* may be characterized as a river of cataracts and rapids. Although it pours down a large volume of water, expanding in places to a width of 600 feet, so numerous are the obstructions, that it can never be adapted to other than canoe navigation.

Within the distance of twelve miles from the junction of the before described streams two portages occur, but the rapids at these places are sometimes run by voyageurs who are acquainted with the channel.

A short distance below Bad Water lake, two falls occur within the space of a little more than a mile, the descent in each case being about nine feet.* The portages are short, and both are on the left bank of the river, and over ridges of chlorite slate.

Great Bekuenesec (Smoky) Falls are situated in township 39, range 30, and are the most picturesque of all the cascades on the Menomonee. The portage is one mile and a half in length; and "within this distance," says Captain Cram, "the descent is 134 feet. This amount is divided into several chutes, with intervening rapids. The general aspect of this series of falls is very picturesque. At every change in the point of view, new and varied beauties are perceived." At the lower falls the water is precipitated in a sheet of foam from the height of forty feet. The river above is compressed between narrow and rock-bound banks, but below it expands into a pool 800 feet in width.

Within the same township are situated the Little Bekuenesec Falls, where the water, in the distance of 250 feet, falls thirty-five feet. The portage on the left bank is short but arduous. The descent of the river within this township exceeds fifteen feet per mile.

*The heights of the falls on the Menomonee are taken from the report of Captain Cram, of the United States topographical corps.—Vide Doc. 33, 26th Congress, 2d session.

Near the west line of township 39, range 29, commence the Sandy rapids, which continue for more than a mile and a half. The bed of the stream is rocky, but the banks are lined with high dunes of sand, which make this portage, which is on the left bank, the most arduous on the Menomonee. The amount of fall here is twenty-one feet.

In the same township, and about two miles below, occur the Sturgeon falls. The descent here, in the distance of one thousand feet, is about thirteen feet. The river is contracted within a span of eighty feet, and rushes between perpendicular walls of rock. The portage is on the left bank, over a ridge eighty-five feet above the stream, at the foot of the rapids.

Before the construction of the dams near the mouth, the sturgeon ascended the river to this point, beyond which they could not go. Here the Indians were wont to resort in great numbers to fish, and the remains of their camp-fires are to be seen along the banks at short intervals. Quiver falls are situated in the south part of township 38, range 28. The descent is nine feet. The portage, one-fourth of a mile long, is on the right bank. The Pemenée (Elbow) falls are five miles below. The principal descent is about eight feet, but immediately above are several ong and difficult rapids. The portage on the right bank is a mile in extent. A short distance below is Chippewa island, (township 37, range 28.) Between this point and the junction of the Brulé and Machigamig the country is rugged and broken. Numerous sharp ridges of slate, and hornblende and feldspar rocks are seen aggregated together, without much system. At most of the portages bare masses of rock are exposed, sometimes precipitous, but oftener worn and polished. The soil is thin, and for the most part sterile. Fires have swept through the woods which once covered the surface, so effectually as to leave hardly a living tree. Blackened trunks rise up on every side as far as the eye can reach. Over this dreary waste the birch and aspen have sprung up, and seem to struggle to gain a precarious support.

Below Chippewa island the soil is more genial. The valley is occupied by sandstones and limestones, and we meet with no sharp ridges, no exposures of rock, over large areas; but the country stretches out into gently rolling plains, traversed by occasional ravines. The river contains many rapids, but no falls.

The Menomonee is one hundred and twenty-two miles in length, or about two hundred including the Machigamig. The whole basin embraces an area of not less than twenty-eight hundred square miles.

For the purposes of navigation it is comparatively worthless, but it affords an indefinite amount of water-power. The lower portions of the valley are covered with extensive tracts of pine, which are beginning to be made available.

In this connexion we may mention the St. Mary's river, connecting together the two lakes, Superior and Huron. It is about sixty miles in length, flowing first a few degrees north of east, then bending abruptly, and flowing a few degrees east of south. Throughout its whole course it occupies the line of junction between the igneous and detrital rocks, forcibly illustrating to what an extent the physical features of a country are influenced by its geological structure.

About twenty miles from the outlet of Lake Superior, at Saut Ste. Marie, the river flows over a sandstone ledge for the distance of three-fourths

of a mile. The descent is between eighteen and a half and twenty-one feet, dependent on the stage of water in Lake Superior. Above the rapids the river shoals gradually from its banks, and the water is not sufficiently deep to float a vessel for several rods from the shore. The banks of the St. Mary's are low, rising in no place over twenty feet above the surface of the water. Efforts have been made, and will doubtless be renewed, to induce the government to construct a canal around these rapids, and thus connect the commerce of Lake Superior with that of the lower lakes.

This connexion is much to be desired, and it is believed that the enhanced value communicated to the public domain would amply repay the expenses of the work. The mere construction of the locks is not all that is required. It will be necessary to extend a pier into the river, above the rapids, to protect the works and insure an entrance to the locks. This pier will be exposed to heavy currents, and at times to large accumulations of ice, and ought to be constructed of the firmest materials, and strongly protected. There are two points on Lake Superior, easily accessible, where materials of the most enduring character may be obtained for this work. Scovill's Point, at the eastern extremity of Isle Royale, affords a tough crystalline greenstone, traversed by divisional planes, which would assist materially in the quarrying. Vessels could approach within a few feet of the rock, and be in a sheltered position while loading.

The Huron islands, composed of granite, afford, perhaps, a still better material. It can be quarried within two hundred feet of the water, and delivered on a vessel by means of an inclined plane or with a derrick. The islands afford a good harbor at all times. This rock is also traversed by divisional seams, which will essentially aid the quarryman in getting it out. This granite, it is believed, will become an article of shipment so soon as there is a free communication with the lower lakes.

The mouths of many of the smaller streams flowing into Lake Superior are silted up with sand and gravel, through which the water filters. In other cases, where the waves break, for the most part, in one direction, the streams are deflected from their true course, and run parallel to the shore for a long distance, until the accumulated back-water breaks through the barrier and makes a passage to the lake.

Table of the principal rivers in the Lake Superior Land District.

Name.	Descent.	Length.	Course.	Area drained.	Outlet.
	Feet.	*Miles.*		*Sq. miles.*	
Montreal	804	34	NW.	420	Lake Superior.
Black	850?	30	NW.	250	Do.
Presqu'Isle	850?	35	NW.	250	Do.
Iron	....	25	N.	75	Do.
Ontonagon	900	85	NNW.	460	Do.
West Branch	....	50	NE	600	Ontonagon.
East Branch	....	45	NW.	250	Do.
Flint Steel	....	25	NW.	70	Lake Superior.
Fire Steel	....	35	NW.	85	Do.
Sleeping	....	15	NW.	100	Do.
Misery	....	20	NW.	75	Do.
Salmon Trout	....	12	N.	40	Do.
Eagle	602	12	NW.	15	Do.
L. Montreal	535[4]	25	E.	30	Do.
Portage	....	4	SE.	200	Do.
Sturgeon	1,074	65	N.	575	Portage lake.
Fall	1,064	12	N.	75	Keweenaw bay.
Huron	1,100	20	NNE.	100	Lake Superior.
Dead (Du Mort)	1,000	40	E.	200	Do.
Carp	688	40	E.	20	Do.
Chocolate	520	25	WNW.	100	Do.
Tequamenen	200	65	NE.	600	Do.
St. Mary's	49	62	SE.	....	Lake Huron.
Carp of Michigan	....	....	....	....	Lake Michigan.
Pine	....	50	S.	....	Do.
Manistee	....	90	SSW.	1,300	Do.
White Fish	....	55	SSE.	450	Do.
Escanāba	1,060	75	SE.	575	Do.
Fort	....	75	SE.	400	Do.
Cedar	....	60	SE.	290	Do.
Menomonee	1,049	122	SE.	1,200	Do.
Brulé	900?	50	ESE.	320	Menomonee.
Mequacumecum	....	50	SSE.	575	Brulé.
Machigamig	1,049	70	SSW.	800	Menomonee.

Mountains]

Mountains perform an important part in the economy of nature. While rivers have been aptly compared to the veins and arteries in the human system, conveying life and energy to the extremities, mountains, with equal propriety, may be likened to the spinal column which supports that system, giving it form and comeliness.

They condense the floating vapors and cause them to descend in grateful showers. They are the repositories of most of the metals used in the arts. They determine the direction of streams—they prescribe the forms of continents.

The mountains of this region nowhere attain an alpine height. They occasionally occur isolated, but are oftener arranged in groups, or in parallel ridges.

1. Two granite belts occur in the Northwest—one forming the axis between the waters of Lake Superior and Hudson's bay; the other between Lake Superior on the north and Lake Michigan and the Mississippi river on the south. The outline of the Canada range is N. 60° E., though subject to minor irregularities. It forms the rim of the Canada shore for more than two-thirds of its extent. The summits of this range are generally rounded, and rarely elevated 1,500 feet above the lake.

On the southern shore, a belt of granite approaches the lake near Dead river, and thence stretches westward, sinking down into a somewhat broken plain southwest of Keweenaw bay. Its widest expansion is about thirty miles. This belt constitutes the Huron mountains, which in places attain an elevation of 1,200 feet above the lake. They do not range in continuous chains, but exist in groups, radiating from a common centre, presenting a series of knobs, rising one above another, until the summit-level is attained. Their outline is rounded or waving—their slope gradual. The scenery is tame and uninteresting. Hemmed in by these knobs, it is not unusual to find numerous lakes and meadows covered with grass, forming an agreeable feature in the landscape. These meadows appear at one time to have been lakes, which have been filled with the detritus brought down from the surrounding hills, or drained in consequence of the water having worn down the barriers which existed at their outlets. Towards the western extremity of the district, the granite reappears in low ridges, and crosses the Montreal within twelve miles of its mouth. There are subordinate patches of granite in other portions of the district, attaining no great elevation, which will be described in the detailed report.

The metamorphic belt folded around the granite is traversed by numerous detached ridges of hornblende and feldspar rocks, ranging in E. and W. direction, and rarely rising more than 200 feet above the surrounding country, and present a more rugged aspect than the granite. A quartz range starts from the lake shore at the mouth of Carp river, and extends westwardly beyond Teal lake. Its outlines are sharp and well-defined, its escarpments bold, with fragments of rock strewn along its base. The boundaries of this group are defined on the accompanying maps.

2. A trap range starts from the head of Keweenaw Point and runs west twenty miles; then, curving to the southwest, crosses Portage lake near its head, and the Ontonagon river twelve miles from its mouth, and is thence prolonged into Wisconsin. Its length is more than one hundred and fifty miles; its width, from one to twelve. Between Iron and Presqu'-

Isle rivers a spur shoots off in the form of a crescent, constituting the Porcupine mountains. Another spur branches off from the main chain on the south, and is prolonged nearly parallel with it for twenty miles. This belt is made up of parallel ranges, presenting step-like or scalar declivities on the side opposite the lake, while the other consists of gradual slopes. Mount Houghton, near the head of Keweenaw Point, rises up like a dome, to the height of eight hundred and eighty-four feet: the Bohemian mountain, near Lac la Belle, is little inferior in height. The valley of Eagle river, on the northwest, is bounded by abrupt, overhanging cliffs, some of which rise to the height of five hundred feet above the surrounding country.

In the vicinity of the forks of the Ontonagon the cliffs are equally bold, and from their summits the eye has an almost unlimited range. To the west, the trap range is distinctly marked for many miles, and the west branch of that stream flows along its base. The highest and most imposing cliffs are north and east of Agogebic lake. Farther west, the ranges are less precipitous and more irregular, much of the country traversed by these rocks consisting of rolling table-lands.

The highest elevation attained by the Porcupine mountains is one thousand three hundred and eighty feet. A remarkable gorge occurs in township 51, ranges 42 and 43. This gorge lies about two miles south of the lake, and in that distance the ground rises about a thousand feet. Suddenly the traveller finds himself on the brink of a precipice five hundred feet deep, at the base of which lies a small lake, so sheltered and hemmed in by the surrounding mountains that the winds rarely ruffle its surface. Gloomy evergreens skirt its shores, whose long and pendent branches are so faithfully reflected on the surface that the eye can with difficulty determine where the water ends and the shore begins. From this lake flows the Carp river, and the beholder occasionally catches a glimpse of its waters as they wind through the narrow valley towards the great reservoir. To the west, and extending for five miles, he sees a perpendicular wall three hundred feet in height—occasionally broken through by a transverse gorge—at the base of which are numerous fragments, which have tumbled from the cliffs above. Still further down is to be seen the rich foliage of the maple intermingled with the dark green of the fir and cedar, and still beyond succeeds a level plain, stretching out for twenty miles, and clothed with a dense growth of trees; while in the distance the Black river hills are seen, blue and indistinct, resting like a cloud upon the horizon.

That portion of the district occupied by the detrital rocks rarely rises three hundred feet above the lake. It is not unusual to see ridges of sand and clay forming considerable elevations. The Grand Sable is a remarkable accumulation of this character, rising to the height of three hundred and forty-five feet. Point Iroquois, at the outlet of the lake, is three hundred and fifty feet in height, and composed wholly of transported materials.

The following list comprises the heights of some of the principal points in the vicinity of Lake Superior. The surface of the lake is assumed as the base line, which is 627 feet above tide-water.

Northern shore (from Bayfield's chart.)

	Feet.
Pie island	850
McKay's mountain	1,000
Thunder cape	1,350
St. Ignace (estimated)	1,300
Les Petits Ecrits	850
Pic island	769
Michipicoten island	800
Gros Cap (estimated)	700

Keweenaw Point, approximately determined by barometer under Dr. Jackson.

Township 58, range 28, southwest quarter section 1, conglomerate ridge	641
Do........do.....section 5, Manganese lake	136
Do........do.....southwestern quarter section 5, trap range	307
Do........do.....line between 12 and 13	467
Do........do.....southwest quartar of 18	252
Do........do.....line between 19 and 20	330
Do........do.....southwest quarter of 29	370
Township 59, range 28, Brockway's mountain	421
Township 58, range 29, section 14, Montreal river	284
Township 58, between ranges 23 and 24, Mount Houghton	884
Township 58, range 29, Bohemian mount, at Lac la Belle	864
Township 58, ranga 30, conglomerate ridge, back of Grand Marais	659
Do........do.....between sections 9 and 10, trap ridge	316
Do........do...........do.......15 and 16, trap ridge	730
Do........do...........do.......15 and 16, Little Montreal river	535
Do........do.....northeast corner of section 21	550
Do........do.....northeast corner of saction 28	568
Do........do.....northeast corner of section 33	696
Township 57, range 30, between sections 5 and six near Gratiot laka	294
Township 58, range 31, southwest quarter section 11, Copper Falls mine	225
Do........do.....south lina of section 14	825
Do........do.....section 24, Northwest mine	630
Do........do.....section 30, Phœnix mine	247
Do........do.....section 36, south boundary	749
Township 57, range 31, section 1, trap range	843
Do........do.....saction 1, south boundary	611
Township 58, range 32, southwest quartar section 36, Cliff mina	588
Do........do.....office	390
Township 57, ranga 32, northwest quarter section 1, North American mine	395
Do........do.....southwest quarter section 2, Albion bluff	800
Do........do.....northwest quarter secton 11, Albion mine	547
Do........do.....office	
Do........do.....south boundary of 28	388
Do........do.....south boundary of 33	475
Township 56, range 32, section 7, Forsyth mine	520

District between Portage lake and the Montreal river.

Township.	Range.	Section.	Fraction.	Locality.	Height.
52	37	35	....	Algonquin location, house........	629
52	37	34	Southwest quarter.....	Highest point of trap range........	759
51	37	15	Southwest corner.......	Cabin of Douglass Houghton Co........	478
51	37	15	....	Trap ridge, one-quarter of a mile east of last point........	655
51	37	15	....	Ridge of conglomerate, one-half mile east of same........	463
51	37	21	....	Trap ridge, one-eighth of a mile southwest of same........	660
51	37	30	....	Trap knob, near southeast corner........	633
50	38	6	....	Trap knob, near northwest corner........	778
50	39	1	....	Trap ridge, 1 mile south of northeast corner of township........	736
50	39	16	....	Cabin of Ontonagon Company........	528
50	39	15	....	Minnesota Company's office........	647
50	39	15	....	Summit of Middle Brother........	758
50	40	36	....	Ontonagon Company's office........	499
49	40	12	....	Trap bluff, above Ontonagon........	416
49	40	5	Southwest corner.......	Clearing of Ohio Trap Rock Company, above Ontonagon........	250
49	41	12	....	Ohio Trap Rock Company's mine........	672
49	41	12	....	High bluff near same........	781
50	40	30	....	Hill of quartzose porphyry........	913
49	41	11	....	High trap bluff........	776
49	41	11	....	Ontonagon river, at base of same........	354
49	42	11	....	Bluff of red porphyry........	1,089
49	42	11	....	Same, above its base........	440
48	49	24	Northwest corner.......	Conglomerate ridge........	586
48	49	24	....	House at location of Montreal River Company........	389
49	42	14	....	Highest point of red porphyry........	1,260
51	43	14	....	Carp lake........	483
51	43	14	....	Cliff at Isle Royale Company's mine........	975
51	43	14	....	Same, above Carp lake........	485
51	43	27	Northwest corner.......	Location of Delavan Company........	587
51	43	27	....	Same, above Carp lake........	106
51	42	27	Northwest corner.......	Union River Mining Company's location........	309
51	42	30	....	Conglomerate hill........	931
51	42	16	....	Ridge of altered sandstone........	601
51	43	32	Northeast corner.......	Location of Croton Company........	690
51	43	32	Southeast corner.......	Cliff of jasper........	1,191

District between Portage lake and the Montreal river—Continued.

Township.	Range.	Section.	Fraction.	Locality.	Height.
50	44	11	....	Highest point of Porcupine mountains....................	1,380
				Isle Royale.	
66	34	21	Northeast quarter.....	Ridge of trap....................	361
66	34	20	Southwest quarter.....	Stream, 10 feet above small lake....................	126
66	34	30	Southeast quarter.....	Summit of ridge near southwest corner of southeast quarter	299
66	35	36	Northwest quarter.....	Northeast corner, summit of ridge....................	409
66	35	36	....	Corner of sections 25, 26, 35, 36....................	99
65	37	24	....	Line between sections 23 and 24, ridge	206
65	37	36	....	Line between sections 35 and 36, ridge	288
65	37	36	....	Lake Desor....................	215
64	37	36	....	North corners of sections 11 and 12....................	309
64	37	36	....	Camp on stream between sections 13 and 14....................	76
63	37	1	....	Ridge of sandstone....................	294
66	34	15	....	Highest point on Isle Royale....................	513
66	34	15	....	Ridge on line between sections 14 and 15	403
66	34	15	....	Southeast corner of section....................	263
66	34	22	....	Ridge on line between sections 22 and 23	234
64	38	32	Northwest corner.....	Beaver island....................	188
64	38	29	....	Ridge on line between sections 29 and 30....................	263
64	38	31	....	Ridge on line between sections 31 and 32....................	175
64	38	20	....	Ridge on line between sections 19 and 20....................	276

NOTE.—For the information of those not familiar with the system of government surveys, it may be stated that the public domain is surveyed into townships, each six miles square, which are subdivided into sections, each one mile square, containing 640 acres. The sections are numbered from one to thirty-six, inclusive, beginning at the northeast corner of the township and counting the first tier of sections from right to left, the second from left to right, and so on, alternately. The townships are numbered north from a base line which starts from Lake St. Clair and runs thence due west to Lake Michigan. The ranges are numbered west from a meridional line which passes through Saut Ste. Marie.

This system, which is an admirable one, was first suggested by Hutchens, who, before the Revolution, belonged to the royal engineers, and subsequently became geographer to the United States. It was early adopted by Congress, and, had it been extended into all the States, would have saved much vexatious litigation as to boundaries, and afforded a vast amount of geographical information, at an inconsiderable expense.

This system is executed with a chain and compass, which, under all the circumstances, is the best which could be devised for this country, where the forests are so dense as to render it impossible to make use of those natural monuments which are essential to connect triangulations. Burt's solar compass is an admirable invention, and ought to be substituted for that in ordinary use in all the public surveys.

CHAPTER II.

CLIMATE.

Objects embraced.—Meteorology.—Effects of the lakes in equalizing the temperature.—Meteorological registers, at various stations.—Mean annual temperature, and that of summer and winter.—Amount of rain.—Course of the winds.—Comparison of the climate in equal latitudes in Europe.—Character of the vegetation.—Range of the cerealia.—Oscillations in the lakes.—The cause.—Periodic rise—Temperature and transparency of the water of Lake Superior.—Evaporation.—Mirage.—Variation of refraction.—Frosts.—Thunder-storms.—Auroras.

Meteorology.—In treating of the climate of this region, we shall use that term in its most extended sense, as comprehending, according to Humboldt, all the changes in the atmosphere which seriously affect our organs—as temperature, humidity, variations in the barometrical pressure, the calm state of the atmosphere or the action of opposite currents of winds, the amount of electric tension, the purity of the atmosphere or its admixture with more or less noxious gaseous exhalations, and, finally, the degree of ordinary transparency and clearness of the sky, which is not only important with respect to the increased radiation of the earth, the organic development of plants, and the ripening of fuits, but also with reference to its influence on the feelings and mental condition of men.*

To this great physicist science is indebted for having first suggested a system of lines, called *isothermal, isotheral,* and *isochimenal,* connecting those places where the mean summer, winter, and annual temperatures have been ascertained. These lines are by no means parallel, various causes conspiring to produce divergencies—such as altitude above the sea, the geographical configuration of a country, the presence or absence of large bodies of water and of mountain chains, the purity of the sky, and the prevailing direction of the winds.

Isothermal lines define the heat and cold of the earth. The line 59° F. traverses the latitude of 43° in western Europe, but descends to latitude 36° in eastern America. The isothermal line of 41° F. passes from latitude 60° in western Europe to latitude 48° in eastern America.

The presence of so vast a body of water as is afforded by the American lakes modifies the range of the thermometer, lessening the intensity of the cold in the winter and of the heat in the summer. By the freezing of the water, a great volume of heat is evolved, and the intense cold of the northern winds is somewhat mitigated in sweeping over the open lakes. In the summer, when the sun, often with unobscured lustre, shines for sixteen hours in twenty-four, the intensity of the heat is modified by the breezes which are cooled in their passage over the surface of the lakes, the water of which is always at a low temperature.

To show the equalizing effects of the lakes on the climate, we need

*Asie Centrale—Tome III.

only refer to the mean temperature of Fort Howard, on Green bay, and Fort Snelling, on the Mississippi:

	Latitude.	Mean T.	Winter.	SummerT.	Range of Ther.
Fort Howard - -	44° 40′	44°.3	20°.5	67°.7	—16 + 99°
Fort Snelling - -	44° 53′	44°.8	16°.3	72°.0	—23 +115°

Thus, during the winter, the mean temperature at the former post is higher; but during the summer it is lower, while the annual temperature is nearly the same. The former is situated in the proximity of large bodies of water, which essentially modify the temperature; while the latter is in the midst of a vast plain, with no mountain chains to break the force of the winds.

[The following tables have been furnished us from the office of the Surgeon General of the United States army, made in pursuance of an admirable regulation, adopted by the Secretary of War as far back as 1819, requiring meteorological observations to be made at the several posts throughout the United States. Three of these posts are within this district, to wit: Forts Wilkins, Brady, and Mackinac, while Fort Howard is but about half a degree removed from its southern boundary. These tables furnish us with satisfactory information as to the mean temperature of the seasons, the prevailing direction of the winds, the serenity of the sky, the amount of rain, &c. We regret that they do not also embrace the fluctuations of the barometer.]

FORT BRADY.

Years.	Aggregate mean temperature.	Thermometer.							Winds.									Weather.				
		Mean temperature.				Maximum heat.	Maximum cold.	Range.	North.	Northwest.	Northeast.	East.	Southeast.	South.	Southwest.	West.	Prevailing.	Fair.	Cloudy.	Rain.	Snow.	Rain and snow, in inches.
		Winter.	Spring.	Summer.	Autumn.				Days.									Days.				
1831..	41.43	14.89	41.49	64.45	44.91	94	20	114	44	61	49	84	46	21	20	40	E. ..	157	64	79	65	.....
1832..	41.61	17 30	38 35	64.99	55.83	91	28	119	81	59	43	50	47	18	19	49	N. ..	172	87	76	31	.....
1833..	41.11	21.01	39.36	61.61	42 48	87	16	103	66	74	37	28	80	18	34	28	SE....	164	68	88	45	.....
1834..	41 43	19.38	39 99	63.68	42 67	91	12	103	30	109	22	34	84	19	35	32	NW..	141	58	97	69	.....
1835..	40.07	16.85	38.61	62.81	42.04	87	20	107	26	104	13	30	90	33	38	31	NW..	185	36			.....
1836..	36.93	16.24	32.71	59.02	39 76	89	25	114	23	99	39	19	127	15	32	12	S ..	164	74	65	63	.....
1837..	36 66	15.98	31.01	57 37	42.29	90	30	120	32	83	42	43	89	29	19	28	SE ...	139	93	91	42	36.92
1838..	37.60	11.71	35.69	62.73	40 29	94	28	122	14	83	25	63	61	25	43	51	NW..	201	39	74	51	34.37
1839..	41.63	21.61	38.11	62.65	44.16	98	28	126	8	138	26	26	98	18	25	26	NW..	200	74	52	29	24.01
1840..	41 14	18.84	42 04	62.15	41.55	90	21	111	20	110	29	40	83	21	32	31	NW..	158	12.4	50	34	33.09
1841..	39.43	18.37	34.02	62.74	42.58	94	26	120	41	71	46	49	44	27	40	47	NW..	146	13.3	55	32	22.74
1842..	38.82	19.48	37.40	57.30	41.12	91	17	108	51.5	42.5	36	39.5	38	76	35	46.5	S...	183	77.5	59.5	45	26.40
Mean.	39.82	17.64	37.39	61.79	42.47	98	30	128	36.37	86.12	33.91	42.12	74	26.6	31	35.1	NW..	169.3	77.2	71.7	47.9	29.58

FORT HOWARD.

Years.	Aggregate mean temperature.	Thermometer. Mean temperature. Winter.	Spring.	Summer.	Autumn.	Maximum heat.	Maximum cold.	Range.	Winds. Days. North.	Northwest.	Northeast.	East.	Southeast.	South.	Southwest.	West.	Prevailing.	Weather. Days. Fair.	Cloudy.	Rain.	Snow.	Rain and snow, in inches.
1831..	44 85	9.04	44.36	70.31	43.69	93	30	123	50	33	45	14	20	90	97	16	SW..	202	79	48	36	.....
1833..	46 62	25.09	45.64	68.99	46.77	99	14	113	49	27	42	28	17	116	42	44	S....	185	84	68	28	.....
1834..	46.88	23.10	46.10	69.98	48.37	96	20	116	46	17	58	28	17	97	34	68	S....	203	139	16	7	.....
1835..	43.94	19.13	44.96	68.33	43.36	96	23	119	60	28	23	36	26	99	45	48	S ...	220	122	15	8	.....
1836..	42.58	21.72	40.80	64.61	43 21	97	17	114	63	41	38	27	24	99	26	48	S....	191	73	70	32	.....
1837..	43 31	24 74	37 08	64.19	47.25	92	18	110	59	27	39	38	34	97	36	38	S....	185	61	86	33	40 55
1838..	42.86	16 56	42.97	69.41	42.68	98	30	128	77	27	21	15	29	117	34	35	S ...	195	54	66	50	37.56
1839..	46.07	25 47	45 66	65 94	47.24	98	16	114	124	23	18	12	26	122	16	24	N....	200	51	74	40	31.28
1840..	44.85	19.92	45.40	67.61	46.49	96	30	126	86	23	14	21	29	132	25	36	S....	208	55	71	32	33.57
Mean.	44.33	20.53	43.66	67.71	45.45	99	30	129	68.22	27.11	33.11	24	24.6	107.6	39.4	40.7	S....	198.7	79.7	57	29.5	35.74

FORT WILKINS.

Year and month.	Mean of thermometer.					Mean annual temperature.	Mean clearness of sky.				+ Heat.	— Cold.	Rain & snow, in inches.
	Sunrise.	9 A. M.	3 P. M.	9 P. M.	Mean.		Sunrise.	9 A. M.	3 P. M.	9 P. M.			
1844, June	50.80	58.04	65.92	52.35	58.35	....	4.03	4.46	4.40	3.56	93°	38°	....
July	56.77	64.38	72.03	60.03	64.96	....	3.77	4.25	5.00	5.22	86	44	....
August	57.70	64.19	69.80	60.70	63.90	....	3.09	3.77	4.64	5.00	84	48	....
September	50.43	58.30	62.40	52.16	56.50	....	3.13	3.83	3.66	5.60	90	34	....
October	37.16	44.48	46.51	38.41	42.22	....	1.70	6.29	2.25	4.51	67	21	....
November	28.20	30.73	31.30	27.93	30.40	....	.73	1.10	1.23	1.86	52	9	....
December	20.93	22.45	20.09	22.22	23.06	....	.41	.96	1.48	1.83	42	6	....
1845, January	19.96	21.70	23.61	20.32	21.77	....	1.48	1.29	.74	1.29	42	0	....
February	20.90	23.03	28.00	22.82	24.10	....	.96	.78	2.21	1.82	53	0	....
March	22.45	26.87	30.41	24.25	25.83	....	2.03	1.96	1.90	4.38	42	2	....
April	31.90	36.30	43.46	35.80	37.66	....	3.13	2.66	4.26	5.06	61	10	....
May	43.67	50.22	59.00	46.32	51.32	41.46	5.87	5.32	5.38	5.64	88	31	....
June	50.76	56.76	62.37	56.56	53.53	....	5.03	4.63	4.80	5.46	76	42	....
July	58.00	64.87	71.00	61.32	64.48	....	4.80	5.19	4.93	5.45	94	48	....
August	64.48	62.85	67.41	57.48	66.33	....	3.97	4.00	4.58	5.67	84	44	....
September	51.72	56.23	64.46	52.50	57.16	....	4.23	4.23	3.23	4.00	78	39	....
October	41.25	44.41	48.67	43.38	45.72	....	2.25	3.19	3.29	2.67	76	26	.50
November	29.33	31.13	33.46	29.33	31.40	....	1.76	1.86	2.30	2.73	50	5	2.91
December	16.38	19.06	20.12	18.16	18.27	....	.93	1.53	1.73	2.50	38	— 4	2.45
1846, January	22.29	25.03	28.74	24.54	25.38	....	1.96	2.53	2.89	3.64	52	— 2	.83
February	16.35	18.53	23.32	18.17	19.83	....	1.46	1.50	2.50	2.60	42	— 9	1.72
March	27.64	32.03	36.84	30.29	32.04	....	2.77	2.96	3.54	3.58	47	12	3.84
April	34.26	40.06	45.96	36.76	40.01	....	4.40	4.70	4.30	6.16	78	12	2.95
May	45.87	53.29	60.19	48.77	53.35	....	6.70	6.83	7.25	6.67	74	33	1.63

MACKINAC.

Months.	Thermometer.							Winds.									Weather.				
	Mean temperature.			Aggregate mean temperature	Maximum of heat.	Maximum of cold.	Range.	N.	NW.	NE.	E.	SE.	S.	SW.	W.	Prevailing.	Fair.	Cloudy.	Rain.	Snow.	Prevailing.
	7 A. M.	2 P. M.	9 P. M.					Days.									Days.				
January	16.96	21.19	18.64	18.93	40	—17	57	6	4	2	1	2	8	....	8	S. ...	8	8	4	11	Cloudy.
February	13.67	21.92	17.39	17.66	38	— 8	46	4	5	....	1	2	4	1	11	W ..	14	6	1	7	Cloudy.
March	23.22	29.93	25.83	26.32	41	— 8	49	7	2	10	7	1	2	1	1	NE. .	12	11	1	7	Cloudy.
April........	29.80	36.23	32.53	32.85	46	10	36	4	3	3	6	....	4	2	8	W...	11	7	8	4	Cloudy.
May	48.12	53.45	50.22	50.59	70	32	38	2	1	....	13	....	4	2	9	E....	15	4	12	....	Cloudy.
June	57.46	66.30	59.76	61.14	84	48	36	3	2	....	10	....	4	....	11	W...	11	7	12	....	Rain.
July...........	63.54	71.87	64.90	66.74	82	54	28	4	6	2	....	1	6	3	9	W...	20	3	8	....	Fair.
August	60.74	68.48	60.64	63.29	82	50	32	3	3	3	3	5	5	3	6	W...	18	2	11	....	Fair.
September	53.30	58.16	53.06	54.84	70	40	30	4	1	5	....	3	11	1	5	S.....	12	5	13	....	Cloudy.
October	45.93	53.22	46.74	48.63	69	29	40	2	1	2	3	4	8	6	5	S.....	11	13	6	1	Cloudy.
November	33.76	38.00	35.03	35.60	62	20	42	2	6	1	5	1	4	6	5	SW..	5	15	3	7	Cloudy.
December......	21.03	25.40	23.80	23.41	42	—16	58	6	3	3	6	4	3	5	1	E....	2	19	1	9	Cloudy.
Mean	38.96	45.35	40.71	41.67	84	17	101	3.9	3.0	2.5	4.5	1.9	5.2	2.5	6.5	W...	11.6	8.3	6.6	3.8	Cloudy.

From these tables we derive the following results: That the mean annual temperature of Fort Brady is nearly two degrees lower than that of Fort Wilkins, although the latter post is nearly a degree farther north. This difference arises from the insular position of Keweenaw Point, which is surrounded on three sides by water.

That, while the annual ratio of rain which falls at Fort Brady is 29.5 inches, at Fort Howard it exceeds 35 inches—an excess which cannot be accounted for by the difference in the mean temperature of the two places, but results from the prevailing direction of the winds; for while the N. and NW. winds prevail at the former post for more than one-third of the year, the S. and SW. prevail for a longer period at the latter.*

That, while there are more rainy days at the former post—the ratio being as 118 to 86—the showers at the latter are more copious.

The direction of the winds is undoubtedly determined, in some degree, by the configuration of the country, pursuing the courses of the lakes.

The observations at Fort Wilkins and Mackinac do not extend through a sufficient number of years to enable us safely to institute comparisons. So far as relates to the annual amount of rain, they are defective.

In the subjoined table we have given the mean temperature of the year, and of the winter and summer, in corresponding degrees of latitude in western and southern Europe; also, the latitudes of places where the several lines of temperature correspond with those of the stations before given.

The first number in the column of temperature represents the mean annual temperature; that which stands in the place of a numerator, the mean temperature of the winter, while the denominator represents the mean temperature of the summer. The European observations are from Baron Humboldt's tables.

From these observations it would appear that the lines of equal temperature on the western coast of Europe, without reference to the elevation, above the sea-level, are about 13° farther north than in the vicinity of the lakes. The climate at Fort Brady, during the whole season, corresponds in a remarkable degree with that of St Petersburg; indeed, the difference of temperature is less than between Fort Brady and Fort Wilkins. While the hills in the region of Fort Brady support a dwarfish growth of terebinthines, (resinous trees,) those in the vicinity of Nautes, in a nearly corresponding latitude in Europe, are covered with the vine.

* Humboldt has given the following as the proportional quantity of rain in different latitudes:

0.	Mean annual depth - - - - - - -	96 inches.
19.	" " " - - - - - - -	80 "
45.	" " " - - - - - - -	29 "
69.	" " " - - - - - - -	17 "

Table showing the mean temperature of the year, and of winter and summer, in corresponding latitudes in Europe and America.

Latitude.	Adjoining the great lakes—height above sea.	Europe—height above sea.	Mean temperature of the year, of summer and winter.	Difference.
47° 27'	Fort Wilkins—647		41°.4 21°.1/61°.4	
48° 50'		Paris—222	51°.6 37°.8/64°.6	10°.2
60° 27'		Abo—0	40°.2 20°.8/38°.3	11°.4
46° 30'	Fort Brady—640		39°.8 17°.6/61°.7	
47° 13'		Nantes—0	54°.6 40°.4/68°.5	14°.8
59° 56'		St. Petersburg—0	38°.8 17°.6/62°.6	15°.8
45° 50'	Fort Mackinac—728		41°.6 20°.5/63°.7	
45° 28'		Milan—390	55°.7 30°.2/73°.4	14°.1
59° 51'		Upsal—0	42°.8 24°.9/60°.2	12°.9
44° 40'	Fort Howard—600		44°.3 20°.5/67°.7	
44° 50'		Bordeaux—0	57°.2 42°.8/71°.2	12°.9
55° 41'		Copenhagen—0	45°.6 30°.7/62°.6	11°.6

The *cerealia*, or common grain, such as wheat, rye, oats, and barley, thrive where the mean annual temperature descends to 28° F., provided that of summer rise to 52° or 53°. The rapid growth of barley and oats adapts them to the short summers of the north; they are found as high as latitude 69° 30′, in Lapland, along with the potato. Wheat, which is a precarious crop, and little cultivated above 58° in western Europe, yields good returns in the temperate zone, when the mean heat, while the grain is on the ground, is 55°; but if no more than 46°, none of the *cerealia* come to maturity.* Indian corn is a precarious crop beyond latitude 45°.

From the tables above given it will be seen that the temperature of this climate is favorable to the growth of the *cerealia*.

Annual plants, remarks Sir John Hooker, which require heat during the summer to ripen their seeds, and which pass the winter in torpidity, in the state of grain, indifferent to the intensity of cold, abound most in those regions where the extremities are greatest; whilst the perennial plants, which can better dispense with the maturing of their seeds, and which are injured by the severities of winter, affect the temperate climates. Of these again, those kinds which have deciduous leaves accommodate themselves best to unequal temperatures; whilst the individuals on which the foliage remains, or *evergreens*, give the preference to districts where the temperature is more constantly equal. Thus, while the shores of the lake are fringed with spruce, balsam, fir, and cedar, the interior of the district produces the maple, the yellow birch, and the ash.

At Fort Brady, the annual ratio of fair days is 168; of cloudy days, 77; rainy days, 71; of snowy days, 47.

The average amount of rain which falls at Fort Brady is 29.5 inches; at Fort Howard, 35.7 inches. These results exhibit a discrepancy which cannot be fully accounted for by the difference in the mean temperature of the two places. The prevailing direction of the winds at the two places may be the true cause. At Fort Brady northwest winds prevail, while at Fort Howard southerly winds predominate.

Phenomena of the waters.—Lake Superior possesses all of the sublimity of the ocean. In gazing upon its surface, whether stretched out like a vast mirror, reflecting the varying tints of the sky, or ruffled by gently-curling waves, or lashed by the fury of the storm, the beholder is alike impressed with a feeling of the grand and the infinite. During a residence of several summers on its borders, our attention has been directed to the fluctuations in the level of its waters; and, while we have failed to detect any ebb and flow corresponding with the tidal action, we have, on the other hand, noticed certain extraordinary swells which appear to be independent of the action of the sun and moon.

These risings attracted the attention of the earliest voyageurs, and they have not failed to record their observations with a minuteness worthy of commendation.

In the Relation for 1670–'71, Dablon uses the following language: "As to the tides, it is difficult to lay down any correct rule. At one time we have found the motion of the waters to be regular, and at others extremely fluctuating. We have noticed, however, that at full moon and new moon

* Murray's Encyclopædia of Geography, vol. I.

the tides change once a day for eight or ten days, while, during the remainder of the time there is hardly any change perceptible. Three things are remarkable: 1st, that the currents set almost constantly in one direction, viz: towards the lake of the Illinois, (Michigan,) which does not prevent their ordinary rise and fall; 2d, that they almost invariably set *against* the wind—sometimes with as much force as the tides at Quebec—and we have seen ice moving *against* the wind as fast as boats under full sail; 3d, that among these currents we have discovered the emission of a quantity of water which seems to spring up from the bottom !"

He supposes that this results from an underground discharge from Lake Superior, and asks, if otherwise, what becomes of the waters of Lake Superior, and whence come the waters of Lakes Huron and Michigan?

In the Relation for the year 1671–'72, Father André thus speaks of the movements of the waters: "I had not partaken of the opinion of those who believe that the lake of the Hurons has an ebb and flow like the sea, because I had not noticed anything very regular during the time I passed on its borders; but I began to suspect that there might be tides in the bay of the Skunks (Green bay) after having crossed Wild Rice river, (Menomonee.) We had left our canoe afloat, the weather being calm. The following morning we were very much surprised to find it on dry ground. I was the more astonished, since I had noticed that the lake had been for a long time tranquil. From that day I resolved to investigate the causes. The first thing I determined was, that the contrary winds, although moderate, did not prevent the flux and reflux. I noticed, besides, that in the river (Fox) which empties into the head of the bay the tide rises and sinks twice in somewhat more than twenty-four hours. The ordinary rise is one foot; the highest tide I saw caused the river to rise three feet, but it was accompanied by a violent northeaster. Unless the northwest winds be very strong, they do not prevent the river from flowing down; so that the discharge is from the middle of the bay—the water rising at each end, according to the hours of the tide.

"We must not be surprised to find this flux and reflux stronger at the head of the bay than on Lake Huron or Illinois; for, supposing the tide to be only one inch in those lakes, it must of course be more marked in this bay, which is from fifteen to twenty leagues long and from five to six in width, and grows narrower and narrower, whereby the water, being reduced to a small space at the head of the bay, must necessarily rise much more than in the lakes, where the space is the widest."

The late Governor Clinton collected a mass of evidence relating to these sudden risings, which is embodied in a memoir communicated to the New York Literary and Philosophical Society;* but, as it is not generally accessible, we will avail ourselves of the most important facts.

L'Hontan† records the following incident: "On the 29th of May, 1689, we came to a little deep sort of river, which disembogues at a place where the water of the lake (Michigan) swells three feet high in twelve hours, and decreases as much in the same compass of time. Our tarrying there three or four days gave me an opportunity of making the remark."

*Vol. II, p. 1.
†Voyage to America, vol. II.

Charlevoix,* who traversed the lakes nearly a century ago, in reference to Lake Ontario, says: "I observed that in this lake, and I am told that the same thing happens in all the rest, there is a sort of flux and reflux, almost instantaneous—the rocks near the banks being covered with water, and again uncovered, several times in the space of a quarter of an hour, even if the surface of the lake was very calm, with scarce a breath of wind. After reflecting some time on this appearance, *I imagined it was owing to springs at the bottom of the lake, and to the shock of their currents with those of the rivers which fall into them from all sides, and thus produce those intermitting motions.*"

Mackenzie, who wrote in 1789,† remarks: "A very curious phenomenon was observed at the Grand Portage, on Lake Superior, for which no obvious cause could be assigned. The water withdrew with great precipitation, leaving the ground dry, that had never before been visible—the fall being equal to four perpendicular feet—and rushing back with great velocity above the common mark. It continued thus rising and falling for several hours, gradually decreasing until it stopped at its usual height."

The following incident is related as having happened to Colonel Bradstreet, who commanded an expedition against the western Indians in 1764: "In returning by way of Lake Erie, when about to land the troops one evening, a sudden swell of the lake, without any visible cause, destroyed several of his boats; but no lives were lost. This extraordinary event was looked upon as the precursor of a storm; and accordingly one soon occurred, which lasted several days."

The following occurrence is related by Governor Clinton, in the memoir before referred to: "On the 30th of May, 1823, a little after sunset, Lake Erie, on the British side, was observed to take a sudden and extraordinary rise, the weather being fine and clear, and the lake calm and smooth. It was principally observed at the mouths of Otter and Kettle creeks, which are twenty miles apart. At Otter creek, it came in without the least previous intimation, in a swell of nine feet perpendicular height, as was afterwards ascertained, rushed violently up the channel, drove a schooner of 35 tons burden from her moorings, threw her upon high ground, and rolled over the ordinary beach into the woods, completely inundating all of the adjacent flats. This was followed by two others of equal height, which caused the creek to retrograde a mile and a half, and to overflow its banks, where water never before was seen, by seven or eight feet. The noise occasioned by its rushing with such rapidity was truly astonishing. It was witnessed by a number of persons.

"At Kettle creek, several persons were drawing a fish-net in the lake, when suddenly they saw the water coming upon them in the manner above described, and, letting go their net, they ran for their lives. The swell overtook them before they could reach the high bank, and swept them forward with great force, but, being expert swimmers, they escaped unhurt. The man who was in the skiff pulling in the sea-line was driven with it a considerable distance over the flat, and grounded on a small eminence, where he remained until the water subsided. There were three successive swells, as at Otter creek, and the effects were the same,

*Journal Historique d'un Voyage de l'Amerique, LXIII.
†Voyage to the Frozen and Pacific Oceans.

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with this difference: the water rose only seven feet. In both cases, the lake, after the swells had spent their force, gradually subsided, and in about twenty minutes was at its usual height and tranquillity."

In 1820, Governor Cass instituted a series of observations at the head of Green bay to determine the changes in the water-level. These observations extended from the 15th of July to the 30th of August; and the following are the results: "That the changes in the elevation of the waters are entirely too variable to be traced to any regular, permanent cause; and that, consequently, there is no perceptible tide at Green bay, which is the result of observation. And such, it appears to me, is the result of calculation, when the laws that regulate solar and lunar attraction, and the limited sphere of their operation, are taken into view."*

Professor Mather, who observed the barometer at Copper Harbor during the prevalence of one of these fluctuations, has published the results of his observations in the journal† before alluded to. He remarks: "As a general thing, fluctuations in the barometer accompanied the fluctuations in the level of the water; but sometimes the water level varied rapidly in the harbor, while no such variations occurred in the barometer at the place of observation. The variations in the level of the water may be caused by varied barometric pressure of the air on the water, either at the place of observation or at some distant points. A local increased pressure of the atmosphere at the place of observation would lower the water level where there is a wide expanse of water, or a diminished pressure under the same circumstances would cause the water to rise above its usual level."

In the summer of 1834, an extraordinary retrocession of the waters took place at Saut Ste. Marie. The river here is nearly a mile in width, and the depth of water over the sandstone rapids is about two and a half feet. The phenomenon occurred about noon. The day was calm, but cloudy. The water retired suddenly, leaving the bed of the river bare, except for the distance of about twenty rods, where the channel is the deepest, and remained so for the space of an hour. Persons went out and caught fish in the pools formed in the depressions of the rocks. The return of the waters is represented to have been sudden, and presented an imposing spectacle. They came down like an immense surge—roaring and foaming; and those who had incautiously wandered into the river-bed had barely time to escape being overwhelmed. Our informants were unable to state whether this occurrence was succeeded by a violent wind or storm; but they all concurred in representing the day as calm.

A similar phenomenon occurred twice the same day, in the latter part of April, 1842. The lake was free from ice, and no wind was prevailing at the time. A few years previously—the precise period our informants could not designate—the current between the foot of the rapids and Fort Brady, which usually flows at the rate of two and a half knots an hour, was observed to set back, and the water rose two feet or more above the usual mark. Some of the soldiers at the fort, in order to satisfy themselves as to the backward flow, jumped into a boat and rowed into the stream, when they found that the boat floated towards the foot of the rapids.

*Remarks on the supposed tides and periodical rise and fall of the North American lakes, by Major (now Brigadier General) Henry Whiting, Silliman's Journal, vol 20, p. 2.
See, also, a paper by General H. A. S. Dearborn in the same journal, vol 16.

†Second series, vol. 6, July, 1848.

These facts are given on the authority of Messrs. Ashmun, Peck, and Bingham—old residents of Saut Ste. Marie.

We have witnessed numerous instances of these ebbings and flowings, which will serve to corroborate the above facts. In the month of August, 1845, while coasting in an open boat between Copper Harbor and Eagle river, we observed the water rise up, at a distance of a fourth of a mile to the northwest, to the height of twenty feet. It curled over like an immense surge, crested with foam, and swept towards the shore, diminishing as it advanced. The voyageurs paused on their oars, having first headed the boat so as to cut the advancing wave. It passed without doing us any injury, and spent its force on the shore. It was succeeded by two or three swells of less magnitude, when the lake resumed its former tranquillity. The cause of this uplift was apparently local, and operated but for a few moments. It could not, like the *bore* at the mouth the Amazon, have been produced by opposing currents. It was late in the afternoon when this phenomenon was observed. The lake was calm; but to the northwest the clouds indicated that different currents of air were moving in opposite directions. Mirage was beautifully displayed, and imaginary islands were seen along the horizon.

While at Rock Harbor, Isle Royale, in the summer of 1847, we witnessed the ebbing and flowing of the water, recurring at intervals of fifteen or twenty minutes, during the entire afternoon. The variation was from twelve to twenty inches; and we took advantage of their recession to catch some of the small lake fish which were left in the pools. The day was calm and clear, but before the expiration of forty-eight hours a violent gale set in.

On the 23d of July, 1848, we went from Copper Harbor to Eagle river, where we arrived in the evening. The day had been calm—so much so, that we were unable to avail ourselves of our sail. In the evening there sprang up an off-land breeze, but we observed a strong current setting in to the river from the lake. The water rose and fell rapidly. The next day a storm commenced and continued for four days.

On the 29th of July, 1849, we were at Rock Harbor, Isle Royale. The wind was light, and a drizzling rain fell all day. The next day, however, a heavy northwester set in—so heavy, indeed, that the propeller then lying in the harbor did not venture out. On the opposite side of the lake, at Copper Harbor, (July 29,) the water was observed to fluctuate at intervals, varying from ten to twenty minutes, and rising higher and higher at each return, until the wharf, placed above the range of the highest stage, as was supposed, was overflowed, as well as the road leading to the warehouse. This continued throughout the day. At Eagle river, twenty-five miles distant, the same fluctuations were observed. The wind, which was not heavy, came from *off* shore, and was therefore opposite to the current from the lake. The next day, as at Rock Harbor, there was a heavy blow from the northwest, the tendency of which would be to accumulate the water on the south shore; but it did not rise as high as on the preceding day, when the wind came from an opposite quarter. These facts show conclusively that these swells, although they precede the winds, do not owe their origin to this source.

This will appear more satisfactorily by consulting a map as to the relative position of the points above mentioned. Isle Royale is about 20 miles distant from the northern and western coast of Lake Superior. Cop-

per Harbor is about 50 miles distant from Rock Harbor, in a south southeast direction. Thus, while these fluctuations were observed at the latter point, the storm had not struck the lake on the Canada side.

Similar occurrences have been noted in other parts of the world. The fluctuations in the Lake of Geneva, which are there called *seiches*, undoubtedly belong to the same class of phenomena.

The intelligent traveller, Von Tschudi,* thus speaks of a singular phenomenon which has in later times often occurred at Callao, and which, in 1841, he had an opportunity of observing: "About two o'clock in the morning, the sea flowed from the shore with greater force than in the strongest ebb; the ships farthest out were left dry, which is never the case in ebb tide. The alarm of the inhabitants was great, when the sea instantly rushed back with increased force. Nothing could withstand its fury. Meanwhile, there was no commotion of the earth, nor any marked change in the temperature."

The great wave frequently observed off Cape Horn and the Cape of Good Hope by mariners may belong to the same class of phenomena.

We have already given Charlevoix's theory to account for these fluctuations. It may be ingenious, but is not even probable. Governor Clinton was disposed to regard them as the result of earthquake movements. If so, a commotion of the land would have been noticed. The facts adduced seem to connect these phenomena with a disturbed state of the atmosphere, since they are, for the most part, succeeded by violent gales. Humboldt remarks that the regularity of hourly variations of the magnetic needle and the atmospheric pressure is undisturbed on earthquake days within the tropics. Von Tschudi says, that in seventeen observations which he made during the earthquakes of Lima, with a good Lefevre barometer, he found, in fifteen instances, the position of the mercury quite unaltered. On one occasion, shortly before a commotion, he observed it 2.4 lines lower than it had been twenty-four hours before. Another time he observed, also on the approach of the shock, a remarkable rising and sinking.

We may regard the earth as surrounded by two oceans—one aerial, the other aqueous. By the laws which regulate two fluids thus relatively situated, a local disturbance in the one would produce a corresponding disturbance in the other. Every rise or fall of one-twentieth of an inch in the mercurial column would be attended with an elevation or depression of the surface of the ocean equal to one inch.† Again, as has been remarked by De la Beche,‡ a sudden impulse given to the particles of water, either by suddenly increased or diminished pressure in the atmosphere, would cause a perpendicular rise or fall, in the manner of a wave, beyond the height or depth strictly due to the mere weight itself. This

* Travels in Peru.

† Whewell on Tides.

‡ De la Beche, (Survey of Cornwall,) quoting from the manuscripts of Mr. Walker, who has devoted much time to the observation of tides, says: "He has foond that changes in the heights of the water's surface, resulting from changes in the pressure of the atmosphere, are often noticed on a good tide-gauge *before* the barometer gives notice of the change. * * * If tide-gauges at important dock-yards show that a sudden change of sea-level has taken place, indicative of suddenly decreased atmospheric weight, before the barometer has given notice of such a change, all that time which elapses between the notices given by the tide-gauge and barometer is so much gained; aod those engaged with shipping know the value of even a few moments before the burst of an approaching hurricane."

sudden impulse would give rise to a series of aqueous waves, which would propagate themselves from the centre of disturbance, like the circles which are observed when a stone is cast into the water. These undulations are perceived in the liquid before the gale sets in. It is not to be expected that the oscillations in the barometer, in all instances, will correspond with those of the water; for Mr. Redfield has shown that storms have sometimes been preceded by an unusual pressure of the atmosphere, the barometer standing remarkably high, and hence he has inferred that there existed around the gale an accumulation of air, under a great degree of pressure, forming a margin. It may frequently happen, that while the *effects* are perceived at the place of observation, the *cause* may be far removed.

Many persons who have resided on the borders of the lakes maintain that, aside from the annual variations in the height of their surfaces, there is a more extended one recurring at intervals varying from five to seven years, while others extend the period to fourteen. The greatest height of water heretofore observed is about six feet. The statistics which have been published* in reference to this rise indicate that the variations in the water-level in a series of years are considerable, but that they do not recur at regular intervals. The meteorological registers kept at various stations show that the annual amount of rain which falls over a given area is extremely variable. Thus, at Fort Brady, where the mean of five years' observations is 29.58 inches, the extremes are 36.92 and 22.44.

Again, the season in the basin of Lake Superior may be rainy, while that in the region of the tributaries of the lower lakes may be dry, and *vice versa;* and thus the lower lakes might be on the rise, while their tributaries failed to discharge their usual volume of water. In proof of this diversity of humidity, it may be mentioned, that during the year 1848, an unusual quantity of rain fell in the basin of Lake Superior, and all of its tributaries were swollen. The lake was gradually rising when we left in September, and at that time had attained a point higher than had been observed for three years previously. On reaching Lake Michigan, in October, we found that that lake began to be sensibly affected by the increased volume of water discharged through the St. Mary's river. On arriving at Cincinnati, the Ohio river was observed to be contracted to less than half its usual volume, so that only the smallest class of boats could navigate its waters.

If meteorological observations were kept at different stations extending through the entire region drained by the great lakes, it would undoubtedly be found that the variations in the water-level corresponded with the variable amount of rain over that area.†

A larger portion of the tributaries of Lake Superior have their origin in a region covered for two-thirds of the year with ice and snow. Late in May the icy fetters are unloosed, and the lake commences rising, and continues to rise until the last of September, when it attains its maximum

*Vide the memoir of Governor Clinton before referred to; Michigan Geological Reports; Ohio Geological Reports, 1838.

†The surface of Lake Superior, on the 12th of August, 1849, was 23½ inches higher than in May, 1847.

It then recedes gradually until the streams begin to discharge their spring floods.

Snow usually commences falling as early as the middle of October, and the ground is covered before the frost has penetrated to a great depth. The amount of snow during the season has been represented as high as thirty feet; but, in consequence of its evaporation, and its change from a crystalline to a granular form, known as *nevé*, it settles, and the actual depth on the ground rarely exceeds four feet. Trappers, in crossing the inland lakes in midwinter, often break through, so slight and unstable is the covering.

The temperature of the water of Lake Superior during the summer, a fathom or two below the surface, is but a few degrees above the freezing point. The following observations show the temperature of the water at different times in different parts of the lake. In the western portion, the water is colder than in the eastern—the surface flow becoming warmer as it advances towards the outlet. The water in these experiments was taken from the surface.

	Fahrenheit.	
	Water.	Air.
June 30, 1849.—To the south of Caribou Island	37°.0	43°.5
July 8, 1849.—In Sand Bay	37°.5	52°.0
July 28, 1849.—Between Keweenaw Point and Isle Royale	39°.5	45°.0
Aug. 13, 1849.—Midway in Keweenaw Bay	49°.0	

During the severe winters, the surface of the lake becomes congealed. When a gale sets in, the ice is seen to undulate and break, and the water to gush through the fissures, until finally the whole mass is set in motion—the fragments clashing against one another, accompanied by loud reports, like volleys of musketry. Long parallel ridges of ice, fifteen or twenty feet in height, are piled up along the shores. We can readily conceive how masses of rock thus entangled might be carried for considerable distances when the ice becomes detached and floats off, and how a cliff might be scratched and grooved.

The waters of the lake possess great transparency, and a tin cup may be seen to the depth of ten fathoms. Coasting along the shores in a calm sunlight day, and looking over the gunwale of the boat, the voyageur seems to be suspended over the floor of the lake, and every fissure in the rock, and every glittering pebble is revealed with wondorful clearness. The light streaming through the transparent medium tinges every object with a brilliant hue.

The evaporation from the surfaces of the lakes must be immense. The combined area of Lakes Superior, Huron, Michigan, and Erie is about 87,000 square miles, and of their basins not less than 335,515 square miles.

It has been estimated that the quantity of water passing into the Niagara river at Black Rock is 22,440,000 cubic feet per minute, or about 80½ cubic miles per annum.* This is equivalent to fifteen inches perpendicular depth of water spread over the area of the whole country drained. The annual amount of rain which falls within this area is about thirty inches. One-half, therefore, of the water which falls within the basin of the upper St. Lawrence is taken up by evaporation, amounting to 11,800,000,000,000 cubic feet.†

At Saut Ste. Marie, the outlet of Lake Superior, the spectator beholds a river nearly a mile in width, and of sufficient depth to float the largest vessel. In its onward progress, it winds among innumerable islands, and ultimately discharges itself, by several mouths, into Lake Huron. At Fort Gratiot, he sees the same river, under another name, after having received all of the tributaries of Michigan and Huron, contracted to a width of little more than three hundred yards, but of increased depth, and he finds it difficult to realize that it is the same river which he saw three hundred miles above.

So, too, the voyageur who has coasted around Lake Superior and gauged the streams which pour their annual floods into the great reservoir, when he stands on the brink of Niagara, and witnesses the fearful plunge of the cataract, is induced to inquire what has become of the superfluous water.

The difference between the temperature of the air and the lake gives rise to a variety of optical illusions, known as *mirage*. Mountains are seen with inverted cones; headlands project from the shore where none exist; islands, clothed with verdure or girt with cliffs, rise up from the bosom of the lake, remain a while, and disappear. In approaching Keweenaw Point, Mount Houghton is the first object to greet the eye of the mariner. Its dome-shaped summit serves as a landmark to guide him in his course. Once or twice, in peculiar stages of the atmosphere, we have observed its summit inverted in the sky long before the mountain itself was visible.

On the north shore, during the summer months, hardly a day passes without witnessing illusions of this kind. The Paps, two elevated mountains near the entrance of Neepigon bay, would at one time appear like hour-glasses, and at another like craters, belching forth long columns of smoke, which gradually settled around their cones.

Thunder cape assumed shapes equally grotesque: at one time resembling a huge anvil with its handle projecting over the lake, at another it appeared as though traversed from summit to base by an immense fissure.

These phenomena are more common on the lakes than on the Atlantic coast, since hardly a day passes during the summer without a more or less striking exhibition of this kind. The amount of refraction, dependent on the state of the atmosphere, is, during the greater part of the summer, extraordinarily variable. The greatest difficulty is experienced in making astronomical observations, from this cause. Observations taken in the afternoon, and generally during the night, are almost invariably worthless. The varying refraction may often be noticed in meridian observations of

* Vide M. Z. Allen's article in Silliman's Journal, January, 1844.

† Dalton found that an evaporating surface of six inches yielded in calm, dry air, at 65° Fahr., 2.62 grains of vapor per minute, and 4.12 in a high wind.

the sun with the artificial horizon, when the two images will be seen to lap over and then separate from each other a great number of times during the few minutes, while the apparent motion of the sun is almost imperceptible. These variations amount to several minutes of altitude; and, of course, on such occasions, no use can be made of the observations. Observations taken in the morning, when a steady brisk breeze was blowing, and the sky free from clouds, were found to be the only ones on which any dependence could be placed.

The same phenomena of rapidly-varying refraction may often be witnessed at sunset, when the sun, sinking into the lake, undergoes a most striking and rapid variety of changes. At one moment, it is drawn out into a pear-like shape; the next, it takes an elliptical form; and just as it disappears, the upper part of its disk becomes elongated into a ribbon of light, which seems to float for a moment upon the surface of the water and then disappear.

Fig. 2.

The annexed cut represents the outline of the appearance of the sun as it went down in the waters of Lake Michigan, June 19, 1849.

The cause of these phenomena can readily be found in the ever varying movement of bodies of differently heated air charged with different amounts of moisture. Those who navigate the lake not unfrequently notice that they pass instantaneously from a current of air blowing briskly in one direction into one blowing with equal force from an opposite direction. The lower sails of a vessel are sometimes entirely becalmed, while a brisk breeze fills the upper.

Frosts, of sufficient severity to turn the leaves, usually occur as early as the middle of September. Snow commences falling by the middle of October, and for more than six months the ground is covered with a fleecy mantle. The streams become locked with ice and remain so until May. The ground does not become frozen to a great depth, and, so soon as the snow disappears, vegetation shoots into life, and the air swarms with myriads of insects. During the long days the sun shines with undiminished splendor, and the influence of its direct rays compensates for the low mean temperature. Spring and summer are mingled. The forest becomes clothed with leaves, and its solitude is enlivened by the song of birds and the hum of insects, before all traces of snow have disappeared.

Notwithstanding the proximity of the lake, the thermometer has a range of 120° in the course of the year. Often in midsummer, when, for several days, the winds come from the southwest, the voyageur experiences a suffocating heat—an enervating depression. The perspiration rolls from him even when unemployed and protected from the glare of the sun by the forest's shade. But, fortunately, these suffocating heats are of short continuance.

In the valley of the Ontonagon, on the 11th of June last, the thermometer rose to 96°.* The wind was blowing from the SW., but brought

* Humboldt remarks that the thermometer nowhere rises higher than 104° F., unless exposed to the influence of bodies which radiate heat. The extraordinary heats of the desert, as indicated by the thermometer, are caused by particles of sand carried through the atmosphere.

with it no refreshing coolness. A little after midday, a dark cloud, emitting from its edges a pale phosphorescent light, rose from the lake, and advanced against the wind. Its approach was indicated by a loud roaring, and, when it reached our encampment, the trees swayed to and fro, and many were prostrated around us. The air was filled with flying leaves and branches. Voyageurs and men instinctively rushed into the river, and remained until the fury of the storm had abated.

Thunder-storms of great violence are not unusual; and the large tracts of prostrate timber frequently met with in the forests, and known as "windfalls," indicate the path of the tornado.

Sudden gusts of wind spring up on the lake, and hence the oldest voyageurs are most inclined to hug the shore.

Instead of seeking for a solution of these phenomena by a resort to natural causes, they ascribe them, like the Scandinavians of old, to the freaks of a crazy old woman, who is endowed with ubiquity:

"Now here, now there, and everywhere."

Before the middle of September, a change in the elements becomes observable. The light and sportive breezes are succeeded by heavy gales, which sweep over the lake, and render coasting exceedingly hazardous.

Auroras, even in midsummer, are of frequent occurrence, and exhibit a brilliancy and extent rarely observed in lower latitudes. The commonest phenomena are these: A dark cloud, tinged on the upper edge with a pale luminous haze, skirts the northern horizon. From this, streaks of orange and blue-colored light flash up, and often reach a point south of the zenith. They rapidly increase and decrease, giving to the whole hemisphere the appearance of luminous waves, and occasionally forming perfect coronæ. They commence shortly after sunset, and continue through the night. The voyageurs regard them as the precursors of storms and gales, and our own observations have confirmed the result. Occasionally broad belts of light are seen spanning the whole arc of the heavens, of sufficient brilliancy to enable one to read.

In the winter these phenomena are much more frequent, and the ground appears tinged with a crimson hue. The aurora indicates a disturbance of the equilibrium in the distribution of terrestrial magnetism, and, according to Dové, may be regarded, not as an externally manifested cause of this disturbance, but rather as a result of telluric activity—manifested on one side by the appearance of light, and on the other by the vibrations of the magnetic needle.*

On one or two occasions we have witnessed the rare and beautiful phenomenon of *parhelia*, or mock suns.

* For a full exposition of these phenomena, consult Humboldt's Kosmos, vol. I.

CHAPTER III.

GEOLOGY OF THE COPPER REGION.

Maps.—Classification of the rocks.—Their composition.—Keweenaw Point.—Range and extent of the trap.—Local details.—District between Portage lake and the Montreal river.—Range and extent.—Metallic contents, and the association of copper.—Porcupine mountains.—Isle Royale.—Its similarity in geological structure to Keweenaw Point.—Range and extent of the trap.—Metallic contents.

That portion of the Lake Superior land district whose geology we purpose to delineate in the following report is represented on the accompanying maps, entitled—

1. A geological map of Keweenaw Point.
2. A geological map of the region between Portage lake and the Montreal river.
3. A geological map of Isle Royale.

These maps comprise the territory known as the *copper region*.

The iron region, though of less extent, but of equal economical value, will form the subject of a subsequent communication.

The rocks which constitute the solid framework, so to speak, of this district, are divisible into two classes, widely different in their origin and composition—the *igneous* and *aqueous*.

Under the first division may be included the several varieties of *trap*—using this term as a generic one—such as greenstone, granular and amygdaloidal trap, basalt, &c. These rocks appear to have been generated within the bowels of the earth by the action of fire, and in some cases to have been protruded in vast irregular masses, forming conical or dome-shaped mountains; at other times, in continuous lines of elevation; while in others they appear to have flowed like lava-currents in sheets over the sands then in the progress of accumulation. The mineral substances which compose these ancient lavas are very various in their nature, but in general it may be said that the predominating rock is one composed of an intimate mixture of labrador, hornblende, and chlorite, though the latter is not an invariable accompaniment.

To the second class, or aqueous formation, may be referred the sandstones, shales, and limestones of this district. They occur in stratified beds, divided into layers, strata, laminæ, &c. The materials appear to have been transported by currents and deposited on the floor of the ocean, where they subsequently became consolidated.

In addition to these, there is another class of rocks which have undoubtedly resulted from the joint operation of igneous and aqueous causes. The materials appear originally to have been ejected through rents and fissures in the crust of the earth to the surface, where they were subsequently transported and ground up by currents and deposited in stratified beds. This class of rocks is termed by M. Prevost* *pluto-neptunean;* and

* Article "Formation," *Dictionnaire Universel d'Histoire Naturelle.*

to this division may be referred the conglomerates and chlorite beds associated with the trap.

The *metamorphic* rocks, or those which were supposed originally to have been deposited by water and subsequently modified by heat, causing them to resemble igneous products, are developed only to a limited extent in the copper region; but in the iron region they are displayed on a scale of vastness, and form the most interesting feature in the physical history of the district.

The mineralogical character of the trappean rocks, being a complex and difficult subject, will be separately described in the chemical part of the report. At present it may, however, be briefly stated that they are in general made up of an intimate mixture of labrador and hornblende, forming a dark-colored homogeneous mass, in which the separate minerals cannot be distinguished by the eye. Chlorite, though not an invariable accompaniment, is often present in a considerable quantity. Magnetic oxide of iron is also a very common ingredient, and sometimes in visible particles, though generally its presence is only betrayed by the action of the rock on the magnetic needle. The variable proportion and nature of the mineral ingredients give rise to a great diversity in the external characters of the mass, which diversity is still further increased by the different circumstances under which different portions of a rock identical in mineral character may have passed from the fluid to the solid state.

The same rock may be found in every shape of transition, from the most compact and homogeneous structure to a light porous mass, filled with cavities, or amygdules, which have often, posterior to the cooling of the rock, been filled with various mineral substances.

For the sake of convenience in describing the local details, and in order to adhere, as much as possible, to the terms already familiarly used by those engaged in mining explorations in this district, we shall include, under the name of trap range, or trappean rocks, all the different varieties of igneous rocks which form the great belt extending from the extremity of Keweenaw Point to the Montreal river, and which also form the greater portion of Isle Royale. When the rock is vesicular in its structure, it is called amygdaloid; when compact, crystalline, or homogeneous, the hornblende predominating, it is called greenstone; when columnar or jointed, as on Isle Royale, it is called basalt. If the homogeneous base contain distinct crystals of feldspar disseminated, it becomes a true porphyry; and the largely crystalline and feldspatic varieties are known as sienitic.

These and many other varieties occur abundantly throughout the district, in belts imposed one upon another. Their position and the changes they have caused in the contiguous detrital rocks will be noticed in describing the detailed geology.

Range and extent.—Commencing at the head of Keweenaw Point, we find the trappean rocks, with the associated conglomerates, emerging to the surface in bold stair-like cliffs, affording many scenes of wild and picturesque beauty. This peculiar physiognomy is characteristic of the whole trap region. Humboldt long ago remarked that each zone had its particular types of animal and vegetable life, but that the inorganic crust of the globe showed itself independent of climatic influences. Everywhere, basalt rises in twin mountains and truncated cones; everywhere porphy-

ritic trap appears in grotesquely arranged masses, and granite in rounded summits.*

The outer belt of trap, occupying the extreme northern portion of Keweenaw Point, (see map,) is less than a mile in width, and preserves a great degree of uniformity throughout its entire course. It forms a segment of a circle, of which the Bohemian mountains may be regarded as the centre. The southern points of Manitou island are dotted with patches of this igneous rock, while the greater portion of the belt has crumbled beneath the action of the lake surf. From the extremity of Keweenaw Point, it extends westerly for about eighteen miles in a curvilinear direction, and passes into the lake at the eastern point of Sand bay. Throughout most of this distance it is protected from the action of the surf by a thick belt of conglomerate, but at several points the water has broken through this sea-wall and excavated spacious harbors in the igneous belt. Copper, Agate, Grand Marais, and Eagle Harbors are included in this belt, and owe their origin to a common cause.

This belt is composed of the varieties of igneous rock known as amygdaloid and brown granular trap. The amygdaloid is best developed in the upper portion of the belt, where it comes in contact with the conglomerate, presenting a dark scoriaceous mass, full of vesicles, somewhat compressed, and bearing a close resemblance to certain modern volcanic products. These vesicles are, for the most part, filled with carbonate of lime, chlorite, agates, carnelians, and amethysts, and minerals of the zeolite family. As we penetrate deeper into the belt, the vesicular structure disappears, and the rock passes into a dark brown granular trap, consisting of an intimate union of hornblende and labrador. This is its general character; and to cite the numerous places where it has been observed, would be to encumber the report with unnecessary detail.

This belt is traversed by veins containing copper and silver, several of which have been mined, but in every instance unsuccessfully. At Eagle Harbor, a company wrought a vein, which, for a time, yielded a rich per centage of copper. Between 5,000 and 6,000 pounds were taken from the vein within a comparatively limited space; but as the miners sank deeper, the copper disappeared. The range of the vein was limited on the south by the conglomerate, and on the north by the lake. At the surface it was two feet in width, and filled in with laumonite and native copper. The shaft was commenced about two hundred feet north of the junction of the rocks, and extended to the depth of ninety seven feet. At that depth the vein had contracted to three inches, and was barren of copper. The best mining-ground is undoubtedly beneath the bed of the lake; but to reach it would require a deep shaft, a long gallery, and an expensive apparatus for ventilation. The company were not disposed to embark in an undertaking, the labor of which was certain, while success was precarious. Several other veins in the northern range were explored by the company, with no better results.

At Hawes's island, near Agate Harbor, a vein was opened by the Cypress River Company, which yielded rich specimens of copper and silver, but, in the downward progress, they disappeared.

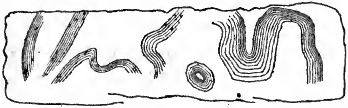
With a single exception, (northwest quarter of section 58, range 30,) we have excluded every tract within this belt from the list of mineral lands, believing that it contains no veins which will be permanently productive.

* Aspects of Nature, vol. II.

To the west of Sand bay about ten miles, and north of the first trappean range, narrow belts of trap have been observed in two places, to wit: on section 28, township 58, range 32; and on sections 1 and 6, between ranges 32 and 33, township 57. The nature of the ground is such that they can be traced but a short distance inland. Whether they are a prolongation of the belt just described, or detached, intercalated masses, it is impossible to determine. The character of the rock is highly amygdaloidal, and chlorite enters largely into its composition. Imperfect indications of veins exist, one of which was explored by the Lake Shore Mining Company yielding little or no copper.

In the more compact varieties, a concretionary structure is sometimes observable. Parallel bands of different colors, a few inches in width, traverse the mass in waving lines, or are arranged in circular forms. This same arrangement is seen more strikingly illustrated in the trap on Hays's Point, near Copper Harbor. The direction and arrangement of these lines is illustrated in

Fig. 3,



the above wood cut. This structure is occasionally found in all igneous rocks, and undoubtedly results from chemical affinity, by which the particles assume a concretionary arrangement.

About a mile south of this trap belt, and separated from it by a deposit of conglomerate and coarse sandstone, which, in places, expands to a thickness of more than 3,000 feet, occurs the northern trap range of Keweenaw Point. It will be seen, by inspecting the map, that these two belts of igneous rocks, in their westerly prolongation, preserve a remarkable parallelism.

This range does not appear to have been the result of one, but of successive overflows; for we not only find the igneous materials arranged in parallel bands, and exhibiting great diversity in external characters, but we also find numerous intercalations of conglomerate of inconsiderable thickness, but extending for miles in a linear direction—these mixed products being associated in regular beds, having a common bearing and inclination, so that the inexperienced observer is inclined to refer the whole to a common origin. This deception is still further increased by observing lines of pseudo stratification in the trap conforming to those of the associated sedimentary rocks.*

This range starts from the head of Keweenaw Point, below Manitou island, and, sweeping round in a crescent form nearly conforming to the trend of the coast, crosses the western arm of Portage lake, where it

*This pseudo-stratification has been observed by De la Beche in the granite of Cornwall, and is supposed by him to result from a tendency in the materials of a cooling mass to arrange themselves in beds, particularly near the surface.—*Geology of Cornwall.*

seems to lose its distinctive character. Towards the valley of the Little Montreal river, it crops out in bare precipitous cliffs; but the northwestern slope is gentle, the rock rarely emerging to the surface.

The following are the elevations of this range at different points, as approximatively determined by the barometer: On section 13, township 58, range 28, 467 feet. On the line between sections 15 and 16, township 58, range 29, about three miles inland from Grand Marais Harbor, 730 feet. Between the Copper Falls and the Northwestern mines, section 24, township 58, range 31, 630 feet. This range skirts the valley of Eagle river on the west, and rises in overhanging cliffs to the height of two or three hundred feet. The Albion cliff, near the northwest quarter of section 10, township 57, range 32, may be regarded as the culminating point, attaining an altitude, as determined by Mr. Hodge, of 800 feet above the level of Lake Superior. Between the Albion mines and Portage lake, the hills present for the most part a rounded outline, and the underlying rocks are covered over with accumulations of water worn materials.

Interstratified with this belt, throughout its entire range, we observe numerous lenticular masses of conglomerate, which appear to affect the courses of veins, as well as their productiveness. The phenomena exhibited by the passage of a vein through different belts of rock will be described in detail under another head.

Local details.—The trap at the eastern extremity of Keweenaw Point (sections 15 and 22, township 58, range 27) is more compact and crystalline than the northern belt before described, and is traversed by small veins containing native copper. Near the centre of section 22, a band of conglomerate from fifty to one hundred feet in thickness is observed, dipping to the north; but it can be traced only for a short distance inland, in consequence of the drift which there reposes on the rocks. A few yards south of the extremity of the point, and near the north line of section 27, a band of conglomerate is observed, attaining a thickness of sixty feet, bearing N. 70° W., and dipping NE. 16°. The underlying trap differs from that which overlies the detrital rocks, being more amygdaloidal, and offering less adhesion between the particles. This is supposed to be a continuation of the great metalliferous belt, as developed at the Cliff, North American, and Northwest mines.

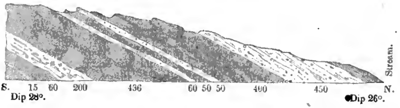
In this township (58) numerous explorations were made by the Boston and Lake Superior Mining Company; and, although they found native copper at several points, they did not succeed in developing a valuable vein. In the adjoining township west (range 28) and north of the Little Montreal river, four alternations of trap and conglomerate were observed. Near the conglomerate ridge, the trap is low; but, north of the Montreal river, it rises in elevated cliffs, which continue through the township, ranging in an easterly and westerly direction. These cliffs are composed of hornblende, in large acicular crystals, imbedded in a paste of labrador. Near their base is seen a band of conglomerate from twenty to fifty feet in thickness, dipping north at an angle of 40°, which can be traced almost uninterruptedly for a distance of twenty-five miles. At the Cliff and North American mines there is a bed of chlorite rock, corresponding in position to this band. The trappean rocks above and below this belt exhibit great differences in lithological character—the upper being highly crystalline, while the lower are amygdaloidal. This belt, lying below the conglomerate, is abundantly stored with copper;

but, being more destructible than the cliffs of overlying greenstone, it is rarely exposed on the surface.

In township 58 the Massachusetts Mining Company opened several veins in the vicinity of the Montreal river, none of which proved productive. The Alliance Company tested to a limited extent a vein on section 8. The Pittsburg and Boston Company also held a location, which they subsequently abandoned.

This ridge extends in an easterly and westerly direction through ranges 29 and 30. In the latter range (township 58, section 15) is situated the Northwest mine. The thin band of conglomerate before described is here exposed on the southern slope of the hill, with greenstone above and amygdaloid and compact trap below. In its passage through the adjoining ranges 36 and 35, (townships 58 and 57,) the trap chain curves rapidly to the southwest, and is prolonged in that direction. The following section represents the relative position of the bedded trap and sandstone on the northern slope of the ridge (section 12) at the Copper Falls mine:

Fig. 4.



The first rock seen in the stream is amygdaloid, resting on sandstone, which bears north 78° west, and dips 26° to the north. The thickness of this trap belt could not be determined, the northern portion of it being concealed by drift. The sandstone is composed of coarse materials, and contains, in places, rounded pebbles. Near the line of junction it exhibits the effects of metamorphism, being dark-colored and firmly cemented. Receding from the line, we find it variegated in color and less compact. To this succeeds another belt of trap, conformable in bearing and inclinaton, below which is another belt of sandstone. Thus there are no less than five repetitions of sandstone and trap within the distance of 2,000 feet. As a general observation, the *upper* portions of these sandstone belts are much more changed by heat than the lower—an important fact, which will be considered in discussing the origin of these rocks and their mode of formation.

The sandstone, where thus exposed, presents a compact texture, breaks with a ringing sound and a conchoidal fracture, and exhibits many of the external characters of jasper. It is traversed by numerous divisional planes, which are quite as distinct as the original lines of bedding. The workings of the Copper Falls Company are in the 436-foot belt.

Between the mouth of Eagle river and the Phœnix Company's works, eleven of these belts, thus intercalated, are noticed within the distance of a mile. Beyond the Albion range these belts cannot be traced, the rocks

being no longer exposed in bare ledges, but covered beneath accumulations of sand, gravel, and clay.

The trap beds thus intercalated are amygdaloidal or granular, but on their upper portions often exhibit a brecciated appearance. They afford numerous examples of veins yielding native copper and silver, but do not expand to a sufficient width to allow extended subterranean workings.

The upper portion of the crystalline belt described as occurring in range 28, township 58, and thence traced through the intervening townships west, is exposed a few rods south of the upper shaft at the Phœnix mine. Here the feldspar predominates over the hornblende, giving the rock a light color. The vein is observed to be disturbed and otherwise affected as it approaches this mass.

The Albion range is capped with this rock, which appears in abrupt precipices two or three hundred feet in height. At the Cliff mine, the upper portion of the precipice is composed of a dark crystalline greenstone—the hornblende largely predominating, which exhibits a mottled or varioloid appearance. At the Albion mine the feldspar again predominates, and the rock becomes in some degree porphyritic. Beneath this is a bed of chlorite rock of a slaty structure, varying in thickness from six to ten feet, below which we meet with a belt of amygdaloid and granular trap. Proceeding along the trend of the Albion range in a southwesterly direction, the amygdaloid is found to dip beneath the surface. At the Cliff mine it is struck near the base of the precipice; but at the Albion mine, three miles distant, it is reached at the depth of ninety seven feet.

This belt, the position and range of which we have endeavored to delineate, is the most metalliferous of any on Keweenaw Point. Throughout its entire extent, it seems to be characterized by well-defined veins. In it are situated the Cliff, North American, Albion, Northwest, and Northwestern mines; and it is reasonable to suppose that others equally valuable will be developed along the line of its outcrop.

Southern trap range.—Returning to the head of Keweenaw Point, we find another range of trap, forming the southern boundary of the valley of the Little Montreal river, and stretching westerly in a line nearly parallel with the northern chain. This is known as the Bohemian range, and differs from the northern both in lithological character and in the mode of its occurrence. While the former, before described, is composed of numerous beds of trap, in the main of the amygdaloid and granular varieties, interstratified with the detrital rocks, the southern range consists of a vast crystalline mass, forming an anticlinal axis, flanked on the north by the bedded trap and conglomerate, and on the south by conglomerate and sandstone.

The contour of the unbedded trap is also very different from that of the bedded trap. We nowhere recognise the stair like structure in the hills; they are either dome-shaped or rounded.

The protrusion of so vast a mass of heated matter has changed in a marked degree the associated sedimentary rocks, causing them to resemble igneous products. Thus, on section 30, township 58, range 27, by the lake shore, is seen a metamorphosed sandstone resembling jasper. Its general bearing is east and west. In places it assumes a vesicular appearance, while other portions are brecciated, and take into their composition chlorite and feldspar. In some hard specimens the lines of stratification can be recognised. The mass is about 100 feet thick, and surmounted by

alternating bands of porphyry and a chlorite rock known as rotten trap, which may be regarded as a volcanic ash. These veins attain a thickness of only a few feet. Proceeding along the southern coast of Keweenaw Point in a westerly direction, at the old fish station (section 35) we again observe this metamorphosed rock forming one of the jutting points of the bay; but here it assumes a different character, as though it had been subjected to a heat more intense and longer continued. All traces of stratification have disappeared, and the rock has become transformed into a red, compact jasper, breaking with a conchoidal fracture, and traversed by numerous divisional planes. Where it comes in contact with the trap below it presents a homogeneous texture. All traces of its mechanical origin are obliterated, and it is difficult to determine where the igneous rock ceases and the aqueous begins.

In section 30, township 58, range 27, west of the Little Montreal river, it is seen again on the coast. The Bare Hills here approach the coast and rise up in overhanging cliffs to the height of 80 feet, and jasper appears to be the prevailing rock. From this point it can be traced inland in a westerly direction, through sections 29 and 30, in the same township and range, to the west line of section 21, township 58, range 29, expanding to a width of about half a mile. The west line of this section passes over Mt. Houghton, an isolated and dome-shaped mountain, rising to the height of 884 feet above the lake, and forming the culminating point in this portion of the region. Its summit is jasper for the distance of 150 feet, and it is difficult to trace any well-characterized lines of stratification in the mass. On the southern flank the mass apparently dips to the SSW. On the northern slope a perpendicular ledge, 20 feet in height, is observed, dipping slightly to the east; to the northeast two low ridges of jasper are seen bearing nearly east and west, and connecting with the Bare Hills by the lake shore. The rock is extremely fissile—so much so, that it is difficult to procure good specimens. In tracing it west, it gradually passes into a compact trap, with here and there an almond-shaped cavity, filled with quartz or calc-spar.

This rock we suppose originally to have been sandstone, and the peculiarities which we have described to have resulted from contact with the mass of trap beneath.

Unsuccessful attempts at mining near the summit of this mountain were made by the Alliance Company.

Near Lac la Belle the Bohemian range attains the height of 864 feet; at its base, and between the trappean and detrital rocks, is a belt of chlorite in foliated masses which expands to about 150 feet in thickness. The occurrence of a bed or mass of this mineral between trap and sandstone is not unfrequently observed in this district. The lower portion of the elevation is here made up of a peculiar rock composed of chlorite and labrador in nearly equal proportions. These two minerals are each in a distinctly crystalline condition, and the feldspathic portion is of a light-reddish color. The mass is filled irregularly with crystals of magnetic iron ore, which occasionally form a large portion of the rock. Particles of copper pyrites are also scattered through it. This variety of rock seems to pass gradually into the dark-colored, fine grained greenstone which occurs on the summit of the mountain.

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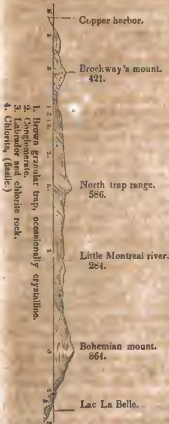
The following section, from Copper Harbor to Lac la Belle, exhibits not only the contours of the country, but the relative association of the detrital rocks and the bedded and unbedded trap:

Fig. 5.



The Bohemian range, as before remarked, forms the line of upheaval of the bedded trap and conglomerate on the north, and the conglomerate and sandstone on the south. The conglomerate, north of the axis of elevation, rarely attains a greater inclination than 45°; but on the southern slope, the sandstone is observed dipping at an angle of 78°. This is beautifully exhibited by the lake shore, on section 36, township 58, range 29. The sandstone is seen in the bottom of the bay, composed of alternating bands of white and red, sweeping round in curves, conformable to the course of the trappean rocks. As we recede a few miles to the south, the strata are observed to be nearly horizontal. In the two adjoining townships west, this range preserves its distinctive character; but beyond, it sinks down into sloping hills two or three hundred feet in height. It exhibits some lithological changes in its course: thus, at the Suffolk mine, now abandoned, (section 16, township 57, range 31,) the rock becomes beautifully porphyritic—crystals of red labrador are scattered through a dark feldspathic base, with sulphuret of copper disseminated in irregular masses.

This range, like the northern one, is traversed by veins for the most part at right angles to the direction of the formation; but, unlike the veins of the northern range; they yield the *sulphurets* of copper, instead of native copper. The only mines now wrought are the Bohemian and Lac la Belle, which will be particularly described under another head. Numerous explorations have been made along the southern boundary of the trap, but in no instance successfully. The abandoned mines are indicated by an appropriate symbol on the accompanying map.

The fissile chlorite rock described as occurring at the base of the Bohemian mountain is found to continue almost uninterruptedly to Portage lake, and always preserving the same relation to the trap and sandstone. The prevailing color is green, but in places it acquires a reddish tinge. The trap, however, in the lower part of township 57, range 33, assimilates more to that of the northern range. At the Forsyth Company's works, (section 33,) a band of greenstone is observed forming the crown of the hill, with amygdaloid resting beneath. In the adjoining township south, the trap is seen to occupy low parallel ridges, and is exposed in the beds of

the water-courses. Much of it is amygdaloidal, intermixed with the greenish and reddish fissile rock before described. Indications of copper exist, but the veins are not well defined.

In the southwest quarter of section 8, the Trap Rock Company perforated the rock to the depth of seventy feet, then drifted sixty-six feet from the vein for the purpose of discovery. The veinstone here consisted of small strings of quartz, calc-spar, and chlorite, arranged in parallel layers, to the width of ten inches, with some copper disseminated; but the indications were not sufficiently encouraging to induce them to continue the work. This vein ranges and dips with the formation—its course being north 50° east; inclination to the northwest 60°.

On the southeast quarter of section 19, township 56, range 32, are the abandoned works of the New York and Michigan Company. Their exploitations were prosecuted on the left bank of a small stream, near the junction of the trap and sandstone. The trap here consists of the reddish and greenish chlorite rock, with imbedded amygdaloid. The surface exhibits few indications of a vein; but, according to the report of Messrs. Grout & Douglass, who explored this location, native copper was found in the small veins and adjoining fissures. A drift was extended 45 feet into the rock; a shaft was also sunk on the opposite bank to the depth of 18 feet, intersecting a belt of the green rock, according to the above authority, highly charged with copper. Although the workmen met with much to encourage, they did not succeed in developing a valuable vein.

On one of the affluents of Torch river, (section 36, township 36, range 33,) the junction of the trap is beautifully displayed. The stream is precipitated over a wall of trap 80 feet in height, and thence winds its way through a deep gorge which it has excavated in the sandstone. The conglomerate differs from the lenticular bands described as occurring with the bedded trap, consisting of arenaceous particles loosely aggregated, and containing, near the base, quartzose pebbles. Patches of green and red ochrey clay occur in different parts of the mass, in a concretionary form.

The red and green chlorite rock, fissile, but not stratified, enveloping masses of amygdaloid, is seen on the left bank of the stream, traversed by seams of quartz and calc-spar, underlying to the NW. 50°. Above this the rock is greenstone, presenting a wall-like appearance, and rising in overhanging cliffs.

The precipice was perforated with a gallery, where the quartz seams are observed near its base, to the distance of one hundred feet. Several seams were crossed in the progress of the work which yielded native copper, but nowhere did the vein concentrate with sufficient power and richness to warrant the expenditure of much capital. This work was prosecuted by the Douglass Houghton Mining Company, under the direction of Messrs. Grout & Douglass, and their report to the company contains a detailed account of their explorations and the character of the rocks.

The trap in this vicinity has not that firmness and liveliness of color which belong to the truly metalliferous belts. Evidences of copper exist, in the shape of small strings and leaders, but they nowhere concentrate and form what miners call a "champion lode."

The Quincy mine, (section 26, township 55, range 34,) near the west arm of Portage lake, affords as good a prospect for mining enterprise as

any which we have observed in this vicinity, although this cannot be regarded as among the best mining-ground.

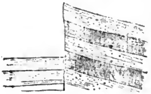
The rock here consists of a dark-brown chlorite trap, with beds of amygdaloid. Between the junction of these rocks native copper is observed in sheets, and disseminated in a vein-stone of calc-spar and chlorite.

The veins, or rather the main lodes, range and dip with the formation, and send off branches at nearly right angles.

The culminating point of the trap here does not exceed 400 feet. The northern flank is covered with detritus, and the rock at rare intervals emerges to the surface. Hence there is really a small portion of the trap range in this vicinity which is adapted to mining.

In the region of Portage lake, the shock by which the bedded trap and conglomerate were elevated does not appear to have been attended with the protrusion of vast crystalline masses, forming a long range, like the Bohemian mountains, or rounded groups, as in the vicinity of the Ontonagon, but simply to have caused a vertical dislocation, lifting up the beds on one side of the fissure, while the corresponding beds on the opposite side remained comparatively undisturbed. There can be no doubt that there existed a deeply-seated and powerful fissure, extending from the head of Keweenaw Point to the western limits of the district, along the line of which the volcanic forces were, at different times, powerfully exerted—similar in character to those in Guatemala, Peru, and Java—the seats of modern volcanic action.

Fig. 6.



The only instance observed in this part of the district, of trap occurring remote from the line of the fissure is in the northest corner of township 49, range 36, fourteen miles southwest of the head of Keweenaw bay. It is known as Silver mountain, (*lucus a non lucendo*,) which rises up isolated and dome-shaped to the height of a thousand feet, and occupies an area equal to three sections. The surrounding plain is covered with deep deposites of clay, resting on sandstone, in nearly horizontal strata. The rock on the summit of the mountain consists of labrador and hornblende, the former largely predominating, and arranged in distinct crystals, with nodules of quartz and chalcedony scattered through the mass. The flanks of the mountain exhibit nearly the same lithological characters. Mining operations were prosecuted there a few years since by the National Company. The hill was perforated by a gallery to the distance of one hundred feet, along the course of a fissure, dipping 63° to the northwest. The attle which lay about the opening was minutely examined, but we failed to detect any traces of copper; nor did the appearance of the wall rock or the fissure afford any well-founded hopes of the presence of metalliferous deposites. The rock at the entrance of the adit appears to have been broken by the elevatory movement, or successive movements, to which the mass had been subjected; for we found the enclosing walls, ground and polished. In other places rounded fragments of the wall-rock were included in the fissure. Near the mouth of the adit the rock was compact, but, on penetrating further, it became highly crystalline. Scoriæ and amygdaloidal patches were observed

in the fissure, as though they had been injected after the upheaval of the mass. Near the summit a dike is seen pursuing a zig-zag direction.

Boulders of granite a foot in diameter and fragments of sandstone are strewn over the summits. Deep grooves and scratches, bearing north 20° east, are seen in this firm and crystalline rock.

Although this is the only instance observed of the protrusion of the igneous rocks through the sedimentary strata in this vicinity, yet evidences of volcanic disturbance exist; and we have reason to believe that eruptive masses have approached near the surface, without breaking through the exterior crust.

Thus, about one-half of a mile from the southern boundary of township 50, a conical knob of sandstone, having a quaquaversal dip, is observed, the strata being much fractured and disturbed. These explorations were conducted by Mr. Hill.

RANGE OF THE TRAP BETWEEN PORTAGE LAKE AND THE MONTREAL RIVER.

External characters.—Between Portage lake and the Fire-Steel river, the trappean rocks are less distinctly marked than on Keweenaw Point. They appear in rounded groups, rather than in parallel chains; but beyond this point they again rise in bold cliffs, which attain an elevation of nearly fourteen hundred feet near Agogebic lake, when they again sink down into a nearly level plain, with an occasional isolated knob. This is their character between the last-mentioned point and the Montreal river. The Porcupine mountains form a lateral branch of the main trap range, and constitute nearly the highest points in the district. The trappean rocks are extremely variable in their lithological character, and among them the following varieties may be recognised:

1. *Compact trap*—varying in color and texture, and occasionally taking into its composition a large proportion of chlorite and a greenish magnesian mineral. Some varieties are exceedingly fine-grained and close in their texture, so that they break almost with a conchoidal fracture; others contain a very large percentage of magnetic oxide of iron, and, if the block have an angular, prismatic form, and remain for some time on the surface, it acquires magnetic polarity. To the presence of so large a proportion of iron is undoubtedly due the irregular variation of the needle so well known to the linear surveyors in the districts underlaid by this class of rocks. The fluctuations of the needle often indicate the presence of the trappean rocks where they are effectually concealed by a thick covering of detritus and soil.

2. *Amygdaloid.*—This variety is found irregularly scattered through the trap, but by no means so abundantly as west of the Ontonagon river. The base of the amygdaloidal trap is generally a fine-grained, homogeneous, dark-colored mixture of hornblende and labrador, with numerous amygdules—some of which are an inch in their longitudinal direction—filled with different mineral substances. Between the Algonquin location and Agogebic lake, epidote frequently accompanies the amygdaloidal trap; west of the last named place, it resembles more nearly the trap of Keweenaw Point, and is associated with large quantities of the zeolites. Where epidote fills the cavities of the trap, it presents a radiated, crystallized texture, and specimens of great beauty are frequently obtained. Generally the vesicles of the epidote are occupied by quartz, often radi-

ated. The quartz is frequently colored green by the presence of epidote, and in such cases affords beautiful cabinet specimens.

The zeolitic minerals often form so large a portion of the rock that it disintegrates and falls to pieces after a short exposure. At the Atlas Mining Company's location, (section 18, township 50, range 44,) now abandoned, they are so abundant that they are found not only in all of the vesicles of the trap, but are distributed through it in large vein like sheets.

3. *Porphyritic trap.*—The base of this rock consists of fine-grained trap, through which are diffused long and distinct crystals of feldspar, which, being white, stand out against the dark base in bold relief. This variety is found in loose blocks south of the trap range; but it has not been observed in place in this portion of the district.

4. *Trap breccia.*—This is a mixture of amygdaloidal trap and quartzose fragments resembling altered sandstone, and seems to have been the product of the interfusion of the two rocks; it is seen at the Cushman location, near the forks of the Ontonagon, (section 36, township 50, range 40,) and also a rock somewhat similar in character is observed at the United States Company's location, a mile or two west.

5. *Epidote trap.*—This variety occurs at many points, especially in the vicinity of the Ontonagon river, occupying a space of several miles in length. The compact trap often passes gradually into it, the epidote replacing the hornblende. The seams of quartz and calc-spar containing copper are almost always accompanied by epidote, which graduates on either side into compact trap.

The varieties of epidote rocks are as numerous as those of the greenstone trap. Both, in fact, occur together over a considerable portion of the district; and though the proper trap is by far the predominating rock, yet there are sections where the epidote forms almost mountain masses. The epidote, however, is rarely pure, but generally mixed with quartz, forming nodules of considerable size. Where the former occurs in seams, or veins, it is much more pure, and possesses a crystalline structure, though distinct crystals of this mineral are of rare occurrence. Like the proper trap, it often becomes amygdaloidal, the amygdules being filled with quartz and calc-spar. On the United States location the trap and epidote are seen in alternating bands, the cavities of the former being filled with epidote and quartz, and those of the latter with quartz and calc-spar.

6. *Compact quartz, or jasper.*—This rock occurs abundantly in mountain masses, the highest summits of the Porcupine mountains being composed of it. It varies in structure considerably at different points. The greater part of it, however, is a homogeneous compact jasper of a deep, brick-red color, sometimes traversed by thin seams lined with crystals of quartz. The jasper is occasionally divided by fine lines or bands, waved or contorted, so as to form an imperfect ribbon jasper, but at other points particles of white quartz are mingled with the red jaspery mass. The compact variety of quartz rock sometimes shows a gradual passage into quartzose porphyry, with occasional imbedded crystals of feldspar.

The quartzose porphyry occurs in very large masses, forming the highest points of the trap range in townships 49 and 50, range 42, on the head-waters of Iron river. It is of a brick-red color, and contains small crystals of white feldspar, not generally exceeding an eighth of an inch in length. Almost invariably, fine rounded particles of vitreous quartz are

found distributed with the feldspar through the jarpery base. It forms an eruptive mass, and often includes fragments of the pre-existing igneous and sedimentary rocks. This porphyry has generally a trappean structure, breaking by natural joints into blocks more or less prismatic.

A singular nondescript rock occurs in a low ledge which crops out on section 33, township 49, range 43. It has a feldspathic base of a light reddish color, through which irregular crystals of red feldspar and small rounded particles of quartz are discernible, intermixed with a greenish mineral, which appears to be epidote. It differs entirely in external characters from any rock found elsewhere in the district.

Range and extent—associated metals.—The trappean range between Portage lake and the Ontonagon river divides the country into two parts—the portion lying on the north being drained by streams which flow at nearly right angles to the formation, while in that portion lying south the streams flow nearly parallel with it. The trap range crosses Portage lake in township 55, ranges 33 and 34—its width being about three miles—and continues in a southwest course nearly parallel with the lake. In township 52, range 36, it contracts to less than a mile in width. Between this point and Portage lake, trap is seen in the beds of the water-courses, and along the water-shed line. Low rounded hills occur, with few exposures of the rock. Within this distance there is no valuable mining-ground, and only one attempt at exploration has been made. The Old Settlers' Company explored a vein, or seam, on section 6, township 52, range 35, the course of which is north 65° east, parallel with the course of the trap. This seam in no place exceeds four inches in width, and is filled with quartz and epidote, with particles of native copper disseminated. The drift was extended for 30 feet. On section 36, township 53, range 36, a shaft was sunk upon a seam of similar character; but the nature of the rock gave little assurance of a valuable vein.

West of township 52, range 33, the trap again expands, occasionally emerging in bold precipitous cliffs. Between this point and the Ontonagon river the rock is in many places metalliferous, and affords good mining-ground. It does not range in continuous chains, but appears in rounded groups or isolated knobs.

At the Algonquin mine (section 36, township 52, range 35) the trap is rather compact, and much mixed with epidote. The ridge here bears northeast, and the escarpment is to the northwest—forming an exception to the general rule found to prevail in this region. At the Douglass Houghton mine, four miles southwest, the trap appears in numerous knobs and short broken ridges, and affords good mining-ground. Masses of veinstone, consisting of quartz colored rose-red by the sub-oxide of copper, are found in the streams, indicating the proximity of veins. On section 15, township 51, range 37, this company have explored an east-and-west vein which promises to yield a profitable return. The rock is a dark-colored, compact trap, occasionally amygdaloidal, traversed by numerous joints, the intervening spaces of variable width, being occupied by quartz and calc-spar. A detailed description of the works will be found under the head of *Mines*.

On the neighboring section, 21, the New York and Michigan Company have made merely surface explorations. There are here two well defined and abrupt ranges of trap crossing the line between sections 16 and 21, in which several veins of metallic copper and blue carbonate of copper

were discovered by Messrs. Grout and Douglass, who explored the location. We found the same appearances here as at numerous other points in the trap range in this vicinity, to wit: epidote occurring massive and intermixed with the trap rock, and containing a small amount of copper. Nothing, however, was found worthy of particular notice. The ridges of trap are elevated about a hundred feet above the general level of the country, while the intervening ground is low and swampy.

About 10 rods southwest of the cabin there is a trap knob which rises to the height of 660 feet—the most elevated point in the immediate vicinity. On the line between 29 and 30 the ground was found to be 633 feet. The trap here is amygdaloidal, with few indications of copper.

In the adjoining township west (township 51, range 38) the trap rises in broken ridges to the height of 150 feet above the surrounding country, presenting mural faces to the south. It consists for the most part of hard, crystalline greenstone, and is traversed by numerous contemporaneous fissures, which are filled with quartz and calc-spar, and contain copper, disseminated, and in masses weighing 15 and 20 pounds. We saw in the northern portion of the belt no well-defined veins; and, altogether, the character of the rock is unfavorable for mining.

The epidote and quartz are occasionally observed in beds, associated with native copper, having a course and dip corresponding with the adjacent stratified rocks.

The Adventurers' Mining Company and the Ridge Mining Company are located in this township—the former on the southeast quarter of section 35; the latter on the southwest quarter of the same section.

In the southwest quarter of section 25 a vein was observed in a ridge which extends across that quarter section, bearing north 55° east, and dipping to the northwest 45°. The veinstone was prehnite and calc-spar, and contained traces of native copper. The foreign matter would not exceed one foot in width, but the brecciated rock occupied three feet.

The Aztec Company are also working a small force in the southeast quarter of section 25, in this township. In the southeastern portion of this township the rock appears more favorable for metals, but the explorations have not been carried sufficiently far to develop the true character of the veins.

The trap range in the adjoining township southwest is highly metalliferous—as much so as any in this portion of the district.

Township 50, *range* 39.—As this is an interesting township in regard to its topographical features, and one in which perhaps more mining and exploring have been done than in any other, we will give a somewhat general description of its geology and topography before entering into a particular description of the several explorations and attempts at mining which have been made. The Ontonagon river runs diagonally across the township in a winding course, separating it into two unequal portions. The three main branches of the stream, called respectively the East, West, and Middle forks, unite in sections 27 and 28, and form a broad river, which, however, is much broken by rapids, and can only be ascended by boats forced up against the current by setting poles. The banks of the river are generally of red clay, sometimes rising one hundred feet above the stream, and worn into precipitous ravines, commonly called "hog-backs," which succeed each other many times in the course of a mile. To travel over them is a task at once laborious and vexatious. The trap

range enters the township at the northeast corner, and pursues nearly a northeast and southwest direction diagonally through it. On the east and west line of section 12, there are two distinct ridges: the northernmost and highest is 736 feet above the lake, at the point of intersection. These ridges continue tolerably distinct and parallel in direction nearly to the Ontonagon, when they gradually break off; and where the river cuts through the range no rock is seen in place, but high clay banks hem in the channel. The terminating knobs of these ridges are conspicuous objects from a distance, and are known as the "Three Brothers." The North and Middle Brothers are the proper terminations of the two parallel ridges; but the South Brother is a spur of the southern ridge. The height of the Middle Brother above the lake is 758 feet; the other knobs and ridges in the township are from 650 to 670 feet.

From the summit of the northern ridge the ground verges very gradually to the lake, there being no other breaks than ravines worn by running water. South of the trap range there is a beautiful level plateau of land, finely timbered with maple and hemlock; then succeeds a broken and uneven country, intersected by numerous gullies. In the beds of the streams sandstone may be seen in place occasionally, though they are mostly excavated in red clay. The current is generally sluggish. The west branch of the Ontonagon flows along the line of junction between the sandstone on the south and the trap on the north; and it was on the left bank of this stream, near the water's edge, in section 31, of this township, that the famous "copper rock," now at Washington, was found. To facilitate its removal, a road was constructed to the main branch of the river on section 20, which is known as the "Copper-rock road."

The trap is flanked on the north by a belt of conglomerate which bears west-southwest, and occupies a width of one-fourth of a mile. Numerous alternating bands of igneous and aqueous rocks are observed in this township, or rather in the northern portion of it.

The trap ranges differ somewhat in lithological character. The northern range, as exposed on section 10, is somewhat porphyritic. Between this and the second range there is a belt of sandstone 100 feet in thickness, which is well exposed on section 16.

The middle range is capped with greenstone, while its base consists of a granular trap, with occasional amygdules dispersed through it, composed of hornblende, feldspar, and chlorite—forming the most metalliferous belt in the region. At the base of this belt a thin band of conglomerate is observed about 10 feet in thickness, dipping north 52°. Between the middle and southern ranges there is probably another band of conglomerate concealed by the soil. The southern range is composed of a dark brown trap, more compact than the former, but likewise metalliferous.

The "South Brother" is somewhat isolated, and may be regarded the most recent in geological age, since the sandstone dips from it on the south, and the bedded trap and conglomerate dip from it on the north.

The principal workings in this township, east of the river, have been prosecuted on sections 15, 16, 21, and 22. The Minnesota Company, on section 16, have a valuable mine, a detailed description of which will be given under the appropriate head.

The Ontonagon Mining Company sank a shaft on section 22 to the depth of 40 feet, which afforded indications of little value. The rock brought to light consisted of a mingled mass of epidote and trap, traversed by seams of calc-spar and quartz, with traces of native copper. Associated with it were particles of oxide of iron, having a metallic lustre, which were mistaken for gray sulphuret of copper.

Another shaft was commenced near the northwest quarter of section 11, but soon abandoned.

The principal shaft sunk by the company was on section 16, near its eastern boundary, and was carried to the depth of 60 feet, through trap which afforded no evidence of a vein.

On the west side of the river, explorations were made on the northeast quarter of section 19, under the direction of Mr. Randolph. The hill was perforated to the distance of 30 feet along the course of a supposed vein, when he found it cut off, as the miners termed it, by a wall of hard, compact trap. Near the seam, and against it, the rock is amygdaloidal, the cavities of which are filled with calc spar, epidote and quartz. In the space of six or eight feet from the seam, the rock graduates into a hard, compact trap, and every trace of a vein is obliterated. The quantity of copper found at this locality was exceedingly small, though some specimens yielded as high as 15 or 20 per cent., and was finely interspersed through the rock.

The Forest Mining Company are exploring some veins west of the river, with very flattering prospects, a description of which will be found under the head of *Mines*.

The mining attempts on section 31, by the Ontonagon Company, will be alluded to in connexion with their operations on the adjoining section in range 40.

In addition to these explorations, numerous shafts have been sunk and adits driven into the clay banks which border the river, by sanguine adventurers in search of mineral wealth. Near the spot where the copper rock was found, numerous attempts of this kind were made. The true sources from which the loose masses of copper have been derived are now fully understood, and fruitless explorations of this kind have long since been abandoned.

Township 50, *range* 40.—The trappean rocks west of the Ontonagon pursue a course which varies but a few degrees south of west. They here expand to a width of little more than four miles, and crop out north of the west branch in bold, overhanging cliffs. About one-third of the northern portion of this township is occupied by the detrital rocks; while the middle, occupied by the igneous rocks, is low, and affords no valuable mining ground. In the southern portion, numerous explorations have been made by the United States and Ontonagon Companies. Those of the latter have been principally confined to section 36. Here a vein-like mass of epidote can be traced from the bottom to the top of a hill, and for a considerable distance along the course of the formation, which bears north 76° east. This mass is nearly vertical, and is one of the largest and best defined which we have seen. It has no perceptible walls, and on either side it may be seen graduating into the trap. A shaft has been sunk about half way down the hill, and a drift extended to intersect it below. Other openings have been made at various points. Although some masses of native copper weighing fifty pounds were extracted, yet the

results, on the whole, could not be deemed satisfactory, for the copper is diffused too sparingly to render the workings profitable. This company also commenced explorations on section 31 in the adjoining township east. A vein-like mass of similar character, bearing nearly east and west, and dipping northwardly, was observed near the base of a cliff, into which a level was driven, without affording much encouragement to continue the work.

The United States Mining Company were located on sections 34 and 35. A superficial examination was made at the base of a trap cliff perhaps one hundred feet in height, where the rock consisted of trap mingled with epidote and quartz, presenting a singular brecciated appearance. No copper was found. Beds of epidote may be seen in this ridge, having an approximate bearing east and west, in which traces of copper exist, but nowhere has it been observed in sufficient abundance to justify mining operations.

On section 35, is a high cliff made up of irregular alternating bands of amygdaloidal trap and amygdaloidal epidote. Surface explorations have only been made here; in fact, there is nothing to warrant extended mining.

Township 49, *range* 40.—The trappean rocks occur only in the extreme northern portion of this township. They rise in isolated knobs and broken ridges, north of the west branch of the Ontonagon, to the height of three hundred and even four hundred feet. Mining operations are for the most part restricted to the upper portions of the bluffs, so that, if systematically pursued, drainage can be effected with ease by means of adits.

The Ohio Trap Rock Company are located on section 5, but most of their explorations have been made on section 12 in the adjoining township west.

Township 49, *range* 41.—The geological features of this township do not differ essentially from that last described. Bold cliffs border the river on the north, through which are distributed vein-like masses of epidote containing copper. The cliffs extend through the township, not continuously, but in broken ridges, and form the principal mining ground. The trap continues northward about five miles, occupying about one half of township 50, but rarely emerges to the surface, and affords few facilities for mining.

Sections 17, 18, and 19, in the western limits of the township, were respectively occupied by the Hope, Ural, and Astor Companies. A bluff, occasionally broken through by ravines, rises to the height of three hundred or four hundred feet above the west branch of the Ontonagon river, in which masses of epidote and quartz, containing considerable copper, are arranged somewhat in the form of veins. In places they were observed to expand to the width of five or six feet, and afterwards contract to a mere seam, and sometimes run out altogether, or re-appear at a higher level in the cliff. There were no well-defined walls observed, and frequently the epidote was seen to pass imperceptibly into compact trap.

These tracts are now abandoned; but if these deposites are found productive after more extended exploitations, mining operations will undoubtedly be resumed at this point.

The Ohio Trap Rock Company have performed much work in a bluff of a similar character on section 12, and at one time their prospects were regarded as highly flattering.

Dr. Gibbs visited this tract in 1848, and from his notes we extract the following information:

"The general character of the rock is a compact trap, containing much epidote mineral, with quartz and calcareous spar. The epidote generally assumes the form of veins, intersecting the trap in different directions, but perhaps chiefly north and south or east and west. The copper is found principally in those veins which have an easterly and westerly direction. In one of these, which dips about 35° to the north, two shafts have been sunk, one of which was 60 and the other 40 feet in depth at the time of our visit, and large quantities of epidote mineral, with quartz and spar, had been raised. The epidote frequently is rich in metallic copper, though as yet it has not been found in large masses. The copper is also disseminated, though sparingly, through the quartz, and affords specimens resembling those from the Cliff mine. The epidote is often beautifully radiated, and, when mixed with the white quartz and bright metallic copper, affords singular and beautiful specimens. At the bottom of the hill, a drift is in progress to meet the two shafts. The hill is about 130 feet in height, and the distance to be driven is about 300 feet, following the apparent course of the vein. Other openings have been made on the location and in this hill. They all present the same general character—namely, a vein-like seam of epidote, containing seams of quartz and calcareous spar, with particles of metallic copper. The fragments of epidote are often covered with a coating of carbonate of copper, evidently derived by decomposition from the metallic copper. Sometimes the decomposed epidote and earthy matter form seams in the rock, which are regarded by the miners as a rich ore. On the whole, the quantity of copper obtained at the locality is sufficient to justify further exploration in proving the real nature of these deposites, though the occurrence of the metal in pseudo-veins will render the ultimate success of the operation a matter of some uncertainty. The appearance of the vein seemed, however, more promising as they descended upon it.

The adit-level has since been constructed, but the vein-like mass did not prove as rich, where intersected, as was anticipated.

The Boston and Lake Superior Company have made explorations on section 11, about one-fourth of a mile further west. The general character of the deposites of copper is similar to that of the Ohio Trap Rock Company. Two vein-like masses of epidote, mixed with quartz and calc-spar, meet at right angles—the one running nearly north and south, the other east and west. Two inclined shafts were sunk to the respective depths of thirty and sixty feet. The bed pitched to the north about 48°, and was thought to become richer in its downward course. This mine is temporarily, if not permanently, abandoned."

This portion of the trap range appears to be richer than any other in the district west of the Ontonagon. It is characterized throughout by these "epidote veins," as they are provincially termed, which in many places offer flattering inducements to miners; but it must be confessed that the explorations thus far have not demonstrated that they can be profitably wrought.

Township 49, *range* 42.—The trap adjoins Agogebic lake on the north, and expands to the width of eight miles. The range of bluffs before described is continued through the southern portion of this township, and presents the same geological features. In the northern portion are

numerous high knobs of quartzose porphyry, in which no traces of copper have been detected. These extend in an east-northeast direction for about six miles, and vary in width from one to two miles. On section 24, known as Boyd's location, explorations to a limited extent have been made.

Near the bed of the stream, by the cabin, occurs a mass of epidote, passing into trap, and containing specks of metallic copper. A small quantity of rock has been thrown out here, but the percentage of copper is very light indeed. At the southeast corner of the location, near the summit of a trap cliff 200 feet in height, occurs another mass of epidote rock, which has been explored in search of copper. This mass is about six feet in breadth by ten in length, and presents superficially some of the characters of a vein, but passes gradually into the trap both above and below, so as to be no longer distinguishable at the distance of a few inches. A few particles of copper are found in the epidote; but appearances, upon the whole, are unpromising.

About one fourth of a mile east of the cabin is the locality known as the "Red oxide vein." The trap is very hard and compact, and contains epidote, which is sometimes stained by carbonate of copper. The seams of the trap are filled with thin plates of a red crumbly substance—probably decomposed laumonite. The epidote has, as usual, some resemblance to a vein. Considerable masses of ore have been obtained from this place, being mostly native copper incrusted with the red oxide, which is probably an after-product from the oxidation of native copper. Near this place is another opening of the same kind; but no copper nor signs of a vein could be discovered. On the whole, there is no reason to suppose that mining operations at this point will be attended with success.

The trap occupies only portions of the first tier of sections in the adjoining township (48) south. On section 6, the Charter Oak Company erected buildings and made surface explorations. The copper bearing rock is similar to that which is characteristic of the whole of this range, and to describe it more in detail would be superfluous. The location is now abandoned.

From this range west to the Montreal river, (we speak not now of the Porcupine mountains,) the country is low and swampy, affording few facilities for mining operations. The rocks rarely emerge to the surface, and, when observed, are in isolated knobs, instead of continuous ranges.

The bed of the Presqu' Isle was examined by us with great care, as well as the country lying west of the river, before the organization of the survey. The conglomerate is seen flanking the trap on the north, as well as intercalated with it in lenticular bands. The junction between the two classes of rocks occurs in section 26.

Township 49, *range* 45.—The trap resembles that of Keweenaw Point, and, near the junction of the different mineral planes, is highly amygdaloidal. The zeolites, so rare in the Ontonagon region, are here very abundant.

A bed of quartz slightly tinged with the sub-oxide of copper is seen in the trap on section 26, near its northern limits. Numerous and apparently contemporaneous fissures traverse the mass, which are filled with prehnite, laumonite, and calc-spar, through which native copper is diffused in small specks. Fissures of greater power, and apparently of a later age, cut the mass in a north and south direction, but they are rarely

metalliferous. Between Presqu'Isle and Black rivers, occasionally, detached knobs of trap are observed, which afford no inducements to mining.

The Cypress River Mining Company erected cabins on section 26, which were subsequently abandoned.

The bed of Black river, above the point where the conglomerate and trap meet, exhibits few exposures of rock. On section 5, township 48, range 46, the Chippewa Mining Company explored a vein in the bed of the stream to some extent, but developed nothing valuable, there being an ill defined vein through which native copper is sparsely disseminated. The trap here rises in hills two or three hundred feet in height, occasionally exhibiting mural escarpments. Beyond these hills southward the country sinks down into a nearly level plain, covered with deep deposites of drift.

Between the Black and Montreal rivers a low range of trappean hills runs parallel with the coast, but in no instance intersects it. To the south the country is low and swampy, but occasionally a trap knob rises up to diversify the monotony of the scene.

The Montreal, a rapid, brawling stream, affords a good section of the rocks. For four miles above its mouth, it dashes through a deep gorge which it has excavated in the rocks, laying bare the bedded trap, conglomerate, and sandstone. The trap is both compact and amygdaloidal. The belt in proximity to the conglomerate is decidedly vesicular and contains an abundance of the zeolitic minerals, in which occasional traces of copper are observed. There are numerous irregular veins of a hard, quartzose material, occasionally stained with copper, bearing north 55° west, with a dip of 45° or 50° northwardly. They are very limited, and we do not consider them as affording any possible indication of valuable lodes.

The Montreal River Mining Company occupied sections 23, 24, 25, and 26, township 48, range 49. The exploitations of the company were very limited, and the locations are now abandoned.

PORCUPINE MOUNTAINS.

These mountains, as will be seen by an inspection of the map, are an off-shoot at nearly right angles from the main range, and form the culminating points in the district, if we except a few points near Agogebic lake. They assume a crescent form—a peculiarity in the trappean rocks, which has been noted by Dr. Percival in his description of the geology of the State of Connecticut. The great mass consists of quartzose porphyry and jasper, though in other portions the amygdaloid is not wanting. Copper has been observed at numerous points, but no valuable lodes have been, nor probably will be, developed. To show the character of the rocks, and the association of the copper, we will advert to the principal points where explorations have been made.

Township 51, *range* 42, *section* 27.—The Union River Company have here made quite extensive explorations—more so than any other company in the region. The seat of their mining operations is about two miles from the mouth of Union river, and is elevated 309 feet above the lake. A bed of trap, 500 or 600 feet in thickness, is included between parallel planes of sandstone, and dips northwest at an angle of 25°. Along the line of junction between the sandstone above and the trap below, and occupying a thickness of about 5 feet, is a bed of amygdaloidal chlorite,

containing copper in bunches and disseminated. On this bed two shafts have been sunk to the respective depths of 100 and 128 feet, and a gallery extended between them. Two vertical shafts were also sunk to intersect the inclined ones. The intention of the company was to make use of the hydraulic power afforded by the stream to raise the attle. Subsequently another shaft was sunk farther north, through sandstone, which intersected the bed at the depth of 120 feet; but the attle thrown out disclosed only a trace of copper. The hanging-wall of sandstone afforded several very good specimens of silver. In contact with the foot-wall there was a thin seam of clayey matter, called by the miners *flucan*, consisting of decomposed chlorite. Near the surface copper was found in considerable masses, some of which weighed 50 pounds; but we could not gather that these occurred in the downward progress of the shafts. The copper here often forms a thin envelope around the exterior of the vesicles of the trap, while the middle is replaced by chlorite or calc-spar. The mass brought to the surface was very meagre in copper, not exceeding one per cent.

In the bed of the stream, a few miles above the mine, is a large mass of quartzose and sparry material in the trap, with chlorite interspersed, which has been explored to some extent. It has a reddish tint, communicated by the sub-oxyde of copper. The workings are now abandonded.

Township 51, *range* 42.—On sections 22 and 27 the Boston Mining Company have made surface explorations, which resulted unfavorably, in a trap belt, which is an extension of that last described. There is a vein of quartz and silicate of lime, containing traces of metallic copper, which bears NE. and SW., and dips NW. at an angle of 30° or 40°, and varies from eight to ten feet in width. The trap here is very much fractured, and contains seams of highly polished chloritic matter, (slickensides.) At the junction of the trap and sandstone, no signs of the bed wrought by the Union River Company are observable.

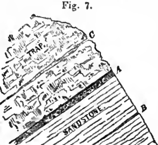
Township 51, *range* 42, *section* 32.—Near the correction line, a shaft has been sunk to the depth of fifteen or twenty feet into the hard jasper, which remains a monument both of persevering industry and misdirected effort; since the difficulty of boring and blasting the close grained and tough silicious rock could only be equalled by the absurdity of attempting to mine a seam of clay in perfectly barren walls.

Township 51, *range* 43.—This township has been the site of much mining exploration, and therefore deserves more than a passing notice. It is much broken by ranges of the Porcupine hills, and mural precipices extend from the centre of section 13 to 30. The highest point is 975 feet above the lake, and on the side opposite the coast presents a vertical face of several hundred feet, with a steep talus of angular fragments at the bottom. The trap, which attains a thickness of several hundred feet, is included within parallel planes of detrital rocks. This range bounds the valley of the Carp river on the north; while to the south, and within the distance of a mile, a second range is observed, composed of amygdaloid, having rounded summits. Still beyond occurs the elevated range of quartz and jasper rocks, in which no trace of copper has been detected. Almost all of the explorations in this township have been made in the first range, near the junction of the trap and sandstone.

On section 14, the Isle Royale Company explored a deposite of copper in some respects similar to that of the Union Company. The sandstone

masses of metallic copper, one of which weighed 55 pounds, were found here dips at an angle of 30° to the north, and has been much altered by contact with the igneous rock. A seam, about a foot in width, consisting of blue plastic clay and chlorite, with rounded fragments of sandstone, is interposed between the two formations. In this seam directly in contact with the trap. An inclined drift was carried on the bed to the depth of 20 feet, but the traces of copper became more indistinct. Several feet above was a seam of calc-spar, from one to four inches in width, and in some places expanding to a foot, intermixed with fragments of the walls, forming a breccia; several feet below, a narrow seam, carrying metallic copper was observed, but it gave no evidence of being valuable. The annexed wood-cut is a section of the cliff at this point. About one-fourth of a mile west, the same company explored one of the vein-like masses of epidote, associated with native copper, like those west of the Ontonagon, bearing north and south, but it afforded little encouragement to persevere.

Fig. 7.



Township 51, *range* 43.—The Delavan Company explored on sections 27 and 28. There are no regular veins or appearances of veins on either of these sections. The rock is epidote, passing into amygdaloidal trap, so intermixed that it is impossible to draw the line of demarcation between them. The amygdules are often filled with epidote, both pulverulent and crystalline—the bright green of the former forming a striking contrast with the dark brown of the latter. A shaft was sunk a few feet in the rock, which here presents a very brecciated appearance, traversed by numerous seams containing calc-spar and the zeolitic minerals. Traces of the gray sulphuret of copper were here observed, and also on section 21; on the adjoining section 32 the Croton Company sank a shaft in a similar rock, but found nothing to induce them to persevere.

On section 30, the Isle Royale Company mined pretty extensively. The character of the rock is similar to that on section 14, before described.

With regard to the Porcupine mountains it may be said, without hesitation, that there are no indications of copper of sufficient promise to warrant mining enterprises. There are no true, well-defined lodes, but irregular seams promiscuously scattered through the trap.

We have endeavored to give, briefly, a synopsis of what has been done in the way of exploitation by the several companies. Originally, all of the trap belt was secured by permits, and even portions of the sandstone. It will hardly be necessary to say that these permits were located at a time when the speculative fever ran high, and when the mere presence of trap was regarded as a sure index of the proximity of valuable lodes of copper. Before the expiration of 1848, nearly all of the companies in this region had abandoned their locations, regarding them as worthless; and, at the end of the succeeding season, there was not, to our knowledge, a white man left.

ISLE ROYALE.

In many respects, Isle Royale may be regarded as the counterpart of Keweenaw Point. On both, the lines of upheaval are nearly parallel, exhibit the same banded structure, and yield the same metallic products.

There are, however, minor differences. The conglomerates here are not developed on so grand a scale—different systems of fracture are found to prevail; but on both shores, the lines of inclination converge towards a common centre, forming a synclinal valley several hundred feet below the ocean-level, which is occupied by the waters of the great lake.

We have seen that the Jesuits formed the most extravagant notions with regard to the mineral wealth of this island; and those notions, though greatly modified, prevailed among the explorers at a later day. Nothing, however, has been revealed to justify those expectations; and the island, for mining purposes, may be regarded as infinitely less valuable than Keweenaw Point, or the region in the vicinity of the Ontonagon.

In an agricultural point of view, it is less valuable than any portion of equal extent in the district. The soil is scanty, and the timber which it sustains is dwarfed and stunted.

Range and extent—metallic contents.—The trappean rocks range through the island in a northeasterly and southwesterly direction, forming numerous ridges, which seldom attain an elevation five hundred feet above the level of the lake. Almost everywhere they present a bedded structure, and the beds display marked lithological differences. The lines of bedding almost invariably are found to be coincident with the lines of stratification in the detrital rocks which occur on the southern portion of the island.

A line drawn from the western extremity of the island, and cutting midway between Siskawit lake and the bay of the same name, would represent the junction between the two formations—the igneous occupying the northern, the aqueous the southern portion. From the eastern point the line curves abruptly, and approaches the shore on the south. There is evidence of a powerful lateral dislocation here, by which one portion of the mass has been forced beyond the corresponding portion, thus interrupting the continuity of the strata. Other evidences of the same phenomena have been observed on other portions of the island, which will be described in the detailed geology. The length of the line occupied by the trap, from Phelps's island, in Washington Harbor, to Passage island, which is an extension of Blake's Point, is fifty one miles; its breadth varies from four and a half to seven miles. The physical obstructions to a successful exploration of the interior of the island are greater than we have encountered in any other portion of the mineral district.

The shores are lined with dense but dwarfed forests of cedar and spruce, with their branches interlocking and wreathed with long and drooping festoons of moss. While the tops of the trees flourish luxuriantly, the lower branches die off and stand out as so many spikes, to oppose the progress of the explorer. So dense is the interwoven mass of foliage that the noonday sunlight hardly penetrates it. The air is stifled; and at every step the explorer starts up swarms of musquitoes, which, the very instant he pauses, assail him. Bad as this region is by nature, man has rendered it still worse. Fires have swept over large tracts, consuming the leaves and twigs and destroying the growth, while the heavy

winds have prostrated the half-charred trunks, and piled them up so as to form almost impenetrable barriers.

As we ascend the ridges, the maple and the birch replace the cedar and the spruce, and the physical obstructions become less formidable. These ridges occur at short intervals, and preserve a great degree of parallelism—bearing northwest and southeast, and are uniformly precipitous on the north, and gently sloping on the south. The valleys between are occupied by swamps, clothed with a dense growth of resinous trees, or with small lakes arranged in chains. The coast of the island is rock bound, and, like Iceland, intersected by numerous *feiords*, or narrow and deeply indented bays.

In describing the detailed geology, we commence at the eastern extremity of the island, and thence proceed west.

Range 32.—Passage island occurs within this range. It is three miles from the nearest point of the main land, and was fabled as possessing rocks of pure copper, so that when a stone was cast against them a sound like that proceeding from brass was emitted. It is two miles in length, and its shores are rock bound, but indented with numerous bays, which afford excellent boat-harbors. The prevailing rock is a dark varioloid trap, which rises near the centre of the island to the height of more than one hundred feet, intersected by numerous veins running north and south, but nowhere affording much inducement for mining enterprise.

Range 33, *townships* 66 *and* 67.—Within these townships are numerous projecting headlands and deeply indented bays, known as the Fingers of Isle Royale. The southern portion of Rock Harbor is bounded by a reef of islands, twenty-four in number, arranged in a linear direction. The rock is a dark-gray trap, not very firm, and occasionally contains amygdules, filled with agate, chlorite, chlorastrolite, calc-spar, &c. A narrow belt of conglomerate is seen intercalated in the trap, bearing northeast and southwest, and dipping southeast 12°, and good exposures occur on Caribou and Mott's islands. A seam of calc-spar, about eight inches in thickness, conforming in course and inclination to the conglomerate, runs through several of these islands, which, in a region remote from masses of limestone, may ultimately prove of economical value. On Mott's island and Shaw's island there are veins of considerable power, but, owing to the proximity of the lake, it was thought that they would never prove valuable, since it would be impossible to free the mines from water.

Scovill's Point.—A cap of dark-gray trap, breaking into cuboidal blocks, and well adapted to the purposes of construction, is here seen, forming the northern boundary of Rock Harbor. It rises in cliffs thirty and even fifty feet in height, forming an excellent sea-wall. From the head of the harbor to the extremity of the point there is not a pebble beach of any extent. Beneath the compact trap is a thin band of amygdaloid:

Fig. 8.

below this a bed of columnar trap, which gradually rises as we advance northward. The columns are arranged in prisms of five, six and seven sides, broken by joints, at short intervals; but we nowhere observed the structure known as ball and socket. The adjoining sketch, taken on the north side of Scovill's Point, will convey a correct idea of the appearance of the columnar trap.

In the compact trap a well-defined vein of considerable power is seen, bearing north of east and south of west, and extending almost uninterruptedly from Ransom to the extremity of the point—a distance of nearly nine miles. This has been explored at different points by the Ohio and Isle Royale Company, by the Siskawit Company, and by Messrs. Shaw and Scovill. The vein stone consists of chlorite, quartz, and calc spar, with native copper in thin sheets and in bunches, and in the compact trap presents favorable indications, but, on entering the columnar trap, it rapidly contracts and becomes worthless. A more detailed description of this vein will be found under the head of *Mines*.

The columnar trap is also seen on Blake's Point and on Silver island. The amygdaloid before described crops out on the southern side of the point. It is of a dark-brown color, and contains numerous agates and vein-like masses of pitch stone. On Blake's Point, the trap attains an elevation of 250 feet, and consists of a dark-gray varioloid greenstone, traversed by numerous belts of sienite, (crystalline feldspar and hornblende,) arranged in strataiform masses. Copper is generally found disseminated through these belts.

On section 33, township 66, a vein can be traced, bearing north 50° east, containing quartz, chlorite, and spar, with considerable copper. It is in the varioloid trap, but, at the depth of 15 feet, one of the sienitic bands occurs, in which the vein is ill defined.

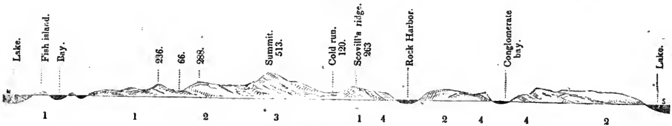
On the northwest quarter of section 33 is one of those natural monuments which instantly attracts the eye of the observer, known as "The Cloven Tower."

The varioloid trap here rises in two columns to the height of about sixty feet, which are separated from one another by an interval of only a few inches in width. They are very symmetrical, resembling obelisks, and altogether form one of the most pleasing features in the scenery of the island.

The varioloid trap skirts the southern coast of Duncan's bay, in bold overhanging cliffs. From their summits, the eye has an almost unlimited range. To the north, the Canada coast can be traced for more than a hundred miles: all of the prominent points—St. Ignace, the Paps, Thunder cape, Pie island, McKay's mountain, and Prince's bay—are distinctly visible. The many inlets around the island, fringed with evergreens, are seen almost beneath the feet. To the east and south, a boundless expanse of water stretches out, unenlivened by sail or other evidence of man's works. In peculiar stages of the atmosphere, the outlines of Keweenaw Point may be traced, resting like a cloud upon the verge of the horizon. The amygdaloid emerges from the base of these cliffs, and, for the most part, forms the underlying rock on Locke's Point. It is of a dark-brown color, and very soft, dipping southerly at an angle of 40°.

Range 34, *townships* 65, 66, *and* 67.—The following section, across the island, nearly through the centre of these townships, north and south, will show the contours of the country and its geological structure.

Fig. 9.



Section of the rocks on Isle Royale.

1. Amygdaloid.
2. Compact trap.
3. Crystalline greenstone.
4. Conglomerate and sandstone.

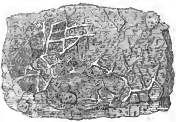
The southern coast in this range is rock-bound, the rocks often rising in rounded, irregular masses to the height of fifty feet. Numerous coves occur, bounded by high cliffs at the entrance, with pebbly beaches at the extremity, which are secure places of refuge in a storm, come from what quarter it may.

The entrance to Chippewa Harbor affords a beautiful section of the intercalations of the sandstone and trap, there being no less than five in the distance of less than a mile. These beds bear SW. and NE., and dip from 12° to 20° to the SE., and respectively vary from a foot to 80 feet in thickness. When traced across the harbor a few rods only in extent, they are found to have been subjected to a powerful dislocation, extending in a NW. and SE. direction, and amounting to 971 feet in a linear direction.

At and near the junctions of these different rocks, marked changes in their lithological characters are observed, which throw much light on their origin.

The *upper* portions of the sheets of trap are highly vesicular, resembling pumice. Fragments of amygdaloid, sometimes rounded, at others angular, are found enclosed in the pumice-like trap, as though they had become detached and afterwards reunited to the mass, while in a molten state. Numerous short and irregular fissures, extending to no great depth, are observed on the upper surface of the trap, in which sandstone has been deposited. The following sketch will explain the nature of the fissures and the position of the included fragments of amygdaloid. Between the ***sandstone above*** and the ***trap below***, it is extremely difficult to determine where the one begins and the other ends. Fragments of amygdaloid, angular or partly rounded, are included in the sandstone—more numerous near the base than at the top of the deposites. Where the sandstone is imposed *on* the trap, there is little evidence of its having been metamorphosed; but, on the other hand, where the trap rests *on* the sandstone, the line of junction is clear and well defined.

Fig. 10.



The trap is less vesicular; and the upper portion of the sandstone belt, for the distance of three or four feet, is converted into a ribbon jasper, having a compact texture. These phenomena have been observed at numerous places both on Isle Royale and Keweenaw Point. The beds of sandstone are not shattered, nor does the igneous rock penetrate in the form of dikes or ramifying veins. All the phenomena indicate that the igneous rocks were not protruded in the form of dikes between the strata, but that they flowed like lava sheets over the pre-existing surface; and that the sand was deposited in the fissures and depressions of the igneous belt, in some cases, while the mass was in an incandescent state.

A bed of crystalline calc-spar, varying in thickness from six inches to two feet, is observed in Chippewa Harbor, and is well adapted to making quicklime. Thin beds of epidote, containing native copper, are also observed, having a bearing and dip conformable to the sandstone.

Such is the nature of the country, that it is impossible to trace these

conglomerate bands to any considerable extent, but they probably wedge out in short distances, forming in fact lenticular bands.

A thin belt of conglomerate lines the northern shore of Conglomerate bay, with a dip of 6° to the southeast, and is protracted thence along the southern shore of Rock Harbor. A thin belt of sandstone occurs about a fourth of a mile north of Ransom and this is the farthest point north along the line of the section at which the purely detrital rocks have been observed.

Between the lake shore and Rock Harbor, embracing the fractional township 65 and the extreme southeast portion of 66, the rock is a dark compact trap, occasionally amygdaloidal, consisting of hornblende, chlorite, and feldspar. The stratiform appearance in places is very marked, particularly near Conglomerate bay, resembling in some respects a sedimentary rock altered by heat. Occasionally a band of crystalline greenstone is found included in the softer rock.

The ridges which form the Fingers of the island, before described, extend through township 66, and present few differences in external characters. The crystalline greenstone which characterizes the middle range, and of which Blake's Point may be regarded as the prolongation, forms the culminating point on this part of the island. In the southwest quarter of section 15 it rises to the height of five hundred and thirteen feet. In crossing the island from Rock Harbor to Amygdaloid island, the traveller encounters a series of sharp ridges, with intervening swamps. The escarpments are invariably on the north side, while on the south the slope is gradual. The clusters of islands and headlands on the northern portion of this township consist of amygdaloidal and compact trap, but afford little encouragement for mining enterprise.

The best mining-ground in this range is near the junction of the two systems of rocks in township 65. The trap is traversed by numerous veins, some of which appear to be metalliferous. The main veins pursue an easterly and westerly course parallel with the formation, but dip to the northwest, thus forming nearly a right angle to the inclination of the sedimentary rocks. Datholite, in many cases, forms nearly the entire gangue. Numerous explorations have been made in this vicinity by the Ohio and Isle Royale Company, which will be noticed under the head of *Mines*.

Range 35. *townships* 65 *and* 66.—Sandstone and conglomerate forms the projecting points by the lake shore in the southwest quarter of township 65. Along the line of junction the same phenomena are observed as at Chippewa Harbor. The coast is lined by heavy masses of trap, with occasional indentations, which afford excellent boat-harbors. Powerful fissures traverse the rock in a northerly direction, and occasionally afford indications of copper. On section 34 a vein of this kind has been explored to a limited extent. Stratiform masses of epidote, containing copper, are also observed, included in the trap.

Receding from the lake shore, the country becomes low, and the rock rarely emerges to the surface. In the south part of the northwest quarter of section 24, amygdaloidal trap was observed, containing the zeolite minerals. It is exposed in the bed of the stream which connects Siskawit lake with the bay, almost in contact with the conglomerate, and is traversed by numerous and apparently contemporaneous fissures, occasionally affording traces of copper.

After crossing the first chain of lakes, the country is intersected by

many sharp ridges, sloping from the summit to the southeast, but breaking off abruptly in perpendicular cliffs to the northwest. The rock is a hard crystalline greenstone, with belts of porphyry similar to those before described.

At the head of McCargoe's cove, the rock is amygdaloidal trap; but between this point and the lake shore, on either side, high cliffs of greenstone occur. The same rock bounds the coast from the outlet of this cove to Todd's Harbor, intermingled with bands of porphyritic trap, having the regularity of sedimentary deposites. This appearance is particularly marked on the main shore, opposite Hawk island. The outer reef consists of amygdaloid which is also seen underlying the greenstone at the eastern extremity of Todd's Harbor. Occasionally veins running north and south traverse the greenstone, but are for the most part pinched and unproductive. The best vein of this class hitherto observed occurs on section 12, in the adjoining range west, and is wrought by the Pittsburg and Isle Royale Company, with a good prospect of success.

Range 36, *townships* 64 *and* 65.—The northern coast of the island in this range is lined with high cliffs of greenstone, so little indented as to afford hardly a boat-harbor. It breaks into cuboidal blocks, and occasionally presents the banded structure before described. Numerous north-and-south veins are observed, and the gangue almost invariably exhibits traces of copper. In the interior, the main range of trap ccurses through the township in a northeasterly and southwesterly direction, but the subordinate ridges are less clearly marked. The southeastern portion of township 65 is low, and the rock rarely emerges to the surface. The same remarks will apply to the fractional township 64. Near the southern border of Siskawit lake, the linear surveyors are said to have discovered a vein of some promise; but it escaped our notice. They also found on the shores of this lake a mass of native copper weighing about twenty pounds. The southern coast in this range consists of conglomerate and sandstone.

Range 37, *townships* 64 *and* 65.—A line drawn from the southwest quarter of section 13, in township 64, to the centre of section 31, will indicate very nearly the junction of the two systems of rocks. In following up the small stream which flows into the northern arm of Siskawit bay, the trap is exposed for the first time on the northwest quarter of section 23. Numerous parallel ridges are intersected in crossing the island, which attain no great elevation. The highest range lies immediately north of Lac Desor, and consists of greenstono, affording no evidence of veins. The northern coast in this range is so girt with rocks that in rough weather it is impossible for the voyageur to effect a landing.

Range 38, *townships* 64 *and* 65.—But a small portion of township 64 is embraced in the trap range, and the heavy accumulations of drift effectually conceal the rock. A ridge of hills, two or three hundred feet high, skirts Washington Harbor on the south, which are so covered with débris that the rock cannot be well explored. Loose masses of veinstone have been observed on the flanks of the hills, which would seem to indicate the presence of veins.

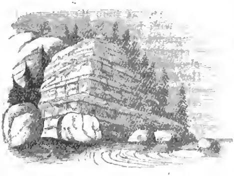
Another elevated ridge occurs between Washington Harbor and the lake shore on the north. The rocks rise in bold, perpendicular cliffs, and from their summits the eye has an almost unlimited range.

The shore is rock-bound, the cliffs ranging in almost unbroken lines, and presenting a wall-like face towards the lake in many places a hundred

feet in height. Hugennin's cove is the only harbor in this vicinity in which the voyageur can take refuge.

The cliffs along the shore exhibit numerous alternations of different igneous rocks. The following sketch was taken on section 28. Thin bands of porphyry are found imbedded in dark compact trap. They bear northeast and southwest, and dip southeast 21°. Whether these alternating bands are due to successive overflows of igneous matter, or are the result of different affinities while the entire mass was in an incandescent state, we are not prepared to say; but are inclined to the former opinion, since the lines of bedding are found to correspond with those of the detrital rocks.

Fig. 11.



At another point on the coast the following section was observed:

	Feet.	Inches.
Compact trap, breaking into cuboidal blocks	15	0
Porphyritic trap	0	3
Compact trap	4	0
Porphyritic trap	0	2
Compact trap	1	6
Porphyritic trap	1	0
Compact trap	1	6
	23	5

These alternations exhibited well-defined lines of junction, and preserved their parallelism along the face of the cliff, as far as exposed. The bearing and dip were the same as in the section before described. The lines of division pursued an undeviating course through the several bands.

A small vein was observed at one point cutting vertically through these bands, and the veinstone exhibited marked changes in its passage through the different belts.

At a point about one-half of a mile to the west, numerous alternations of compact trap and amygdaloid were observed, having the same regularity in bedding and inclination.

We have observed this banded structure in the igneous rocks, at short intervals, from Blake's Point nearly to Washington Harbor, a distance of forty-five miles; and throughout the entire extent of the island they present a remarkable uniformity in bearing and inclination. They were, undoubtedly, deposited at first in nearly horizontal sheets, and owe their present inclination to the same upheaval which uplifted the associated sedimentary rocks. We regard them as purely igneous products, and not as the result of metamorphism.

Range 39, *townships* 63 *and* 64.—Between Hugennin's cove and Washington Harbor, the trap lines the coast in overhanging cliffs a hundred and fifty feet in height. In rounding the end of the island, where

the different beds of unequal firmness have been exposed to the action of the surf, numerous coves are observed walled up on either side, and skirted at the extremities by agate beaches. Rounded masses of prehnite containing copper are abundant on all of the islands, and several beautiful specimens of silver have been picked up in the same association.

Phelps's island, on the southern side of the harbor, holds out strong inducements for mining enterprise. On the southeast shore (section 10) is a vein, bearing south-southeast, 18 inches wide, containing calc-spar, prehnite, and native copper. Still further to the east is another vein of great power, bearing nearly north and south, and thirty inches in width. The veinstone consists of quartz, laumonite, and prehnite, with native copper disseminated.

On the southeast quarter of the same section is another copper-bearing vein, well defined, and seven inches in width.

Appended to this chapter will be found a tabular list of the tracts in this district supposed to contain copper.

In designating such lands as were regarded as mineral, we have been governed by the following considerations:

All of that portion underlaid by sandstone and conglomerate has been excluded—experience having demonstrated that, although they contain traces of copper, no valuable lodes need be expected.

We have restricted the mineral lands to such portions of the trap ranges as were sufficiently elevated for mining purposes, where the rock was exposed on the surface, and, from its external characters and proximity to veins of known value afforded evidence of productive lodes.

Although the Porcupine mountains afford good exposures of the rock, and contain abundant traces of copper, neither the character of the veins nor of the containing rocks affords a reasonable prospect for successful mining. For this reason, we have included no portion of it in the list of mineral lands. The same remarks will apply to the trap range in the vicinity of the Montreal river.

In designating the mineral lands on Isle Royale, we have encountered much difficulty. The metalliferous bands, as we have seen from the detailed geology, are extremely narrow, particularly in the northern portion; but the physical obstructions were such as to prevent a successful exploration inland. We have accordingly designated such tracts as were sufficiently elevated above the lake for mining purposes, and gave evidence of being metalliferous, without reference to the thickness of the belts.

List of the mineral lands of Keweenaw Point, Lake Superior lan district.

Section.	Part.	Township north.	Range west.
7	SW. ¼	58	27
17	W. ½	58	27
18	All	58	27
19	N. ½	58	27
20	NW. ¼	58	27
4	S. ½	58	28
5	S. ½	58	28
6	S. ½	58	28
7	All	58	28
8	All	58	28
9	All	58	28
10	All	58	28
13	All	58	28
14	N. ½ and SE ¼	58	28
15	NE. ¼	58	28
16	S. ½	58	28
17	S. ½	58	28
18	SE. ¼	58	28
19	NE. ¼	58	28
20	N. ½ and SE. ¼	58	28
21	All	58	28
22	W. ½	58	28
24	N. ½	58	28
27	NW. ¼	58	28
28	N. ½	58	28
1	S. ½	58	29
2	S. ½	58	29
7	All	58	29
8	All	58	29
9	All	58	29
10	S. ½	58	29
11	All	58	29
12	All	58	29
13	N. ½	58	29
14	N. ½	58	29
15	N. ½	58	29
16	N. ½	58	29
17	N. ½	58	29
18	N ½	58	29
19	S ½	58	29
20	S. ½	58	29
21	S. ½	58	29
22	S. ½	58	29
23	All	58	29
24	N. ½	58	29
25	N. ½	58	29
26	N. ½	58	29
27	All	58	29
28	All	58	29
29	All	58	29
30	All	58	29
31	N ½	58	29
32	N ½	58	29
6	NW. ¼	58	30
7	E. ½ and SW. ¼	58	30
8	All	58	30
9	All	58	30
10	All	58	30
11	All	58	30
12	All	58	30

List of the mineral lands of Keweenaw Point—Continued.

Section.	Part.	Township north.	Range west.
13	N. ½	58	30
14	N. ½	58	30
15	All	58	30
16	All	58	30
17	All	58	30
18	All	58	30
19	N. ½	58	30
20	NW. ¼	58	30
25	All	58	30
26	S. ½	58	30
27	S. ½	58	30
28	S. ½	58	30
29	SE. ¼	58	30
31	All	58	30
32	All	58	30
33	All	58	30
34	All	58	30
35	N. ½	58	30
36	N. ½	58	30
4	NW. ¼	57	30
5	N. ½ and SW. ¼	57	30
6	All	57	30
11	SE. ¼	58	31
12	S. ½	58	31
13	All	58	31
14	All	58	31
15	S. ½	58	31
19	S. ½ and NE. ¼	58	31
20	All	58	31
21	All	58	31
22	All	58	31
23	All	58	31
24	All	58	31
28	NW. ¼	58	31
29	W. ½ and NE. ¼	58	31
30	All	58	31
31	NW. ¼	58	31
36	S. ½	58	31
1	N. ½ and SW. ¼	57	31
2	E. ½ and SW. ¼	57	31
3	S. ½	57	31
4	S. ½	57	31
8	NE. ¼	57	31
9	N. ½	57	31
10	N. ½	57	31
11	NW. ¼	57	31
25	S. ½ and NE. ¼	58	32
35	S. ½ and NE. ¼	58	32
36	All	58	32
1	N. ½	57	32
2	All	57	32
3	S. ½ and NE. ¼	57	32
10	All	57	32
11	W. ½	57	32
15	W. ½	57	32
16	SE. ¼	57	32
21	All	57	32
22	S. ½	57	32
26	W. ½	57	32
27	All	57	32
28	N. ½ and SW. ¼	57	32

List of the mineral lands of Keweenaw Point—Continued.

Section.	Part.	Township north.	Range west.
29	E. ½	57	32
31	E. ½ and SW. ¼	57	32
32	W. ½	57	32
33	E. ½ and SW. ¼	57	32
34	W. ½ and NE. ¼	57	32
35	S. ½ and NE. ¼	57	33
36	SW. ¼	57	33
4	W. ½	56	32
5	S. ½ and NW. ¼	56	32
6	E. ½	56	32
7	N. ½ and SE. ¼	56	32
8	N. ½ and SW. ¼	56	32
17	W. ½	56	32
18	E. ½	56	32
19	All	56	32
20	W. ½	56	32
30	W. ½	56	32
2	W. ½	56	33
3	SE. ¼	56	33
10	SW. and NE. ¼	56	33
11	N. ½	56	33
25	SE ¼	56	33
35	SE ¼	56	33
36	All	56	33
1	NW. ¼	55	33
2	S. ½ and NE. ¼	55	33
3	SE. ¼	55	33
10	S. ½ and NE. ¼	55	33
11	NW. ¼	55	33
15	NW. ¼	55	33
16	All	55	33
20	S. ½ and NE. ¼	55	33
29	NW. ¼	55	33
30	N. ½	55	33
23	SE. ¼	55	34
24	N. ½ and SW. ¼	55	34
25	N. ½ and SW. ¼	55	34
26	All	55	34
27	SE. ¼	55	34
35	SE. ¼	55	34
36	S. ½	55	34

List of the mineral lands in the region between Portage lake and the Montreal river.

Section.	Part.	Township north.	Range west.
25	SE. ¼	52	37
35	E. ½ and SW. ¼	52	37
36	All	52	37
1	NW. ¼	51	37
2	N. ½ and SW. ¼	51	37
10	E. ½ and SW. ¼	51	37
11	W. ½	51	37
15	N. ½ and SW. ¼	51	37

List mineral lands between Portage lake and Montreal river—Continued.

Section.	Part.	Township north.	Range west.
16	S. ½	51	37
21	All	51	37
22	NW. ¼	51	37
29	SW. ¼	51	37
30	S ½	51	37
31	N. ½	51	37
32	NW. ¼	51	37
25	W. ½ and SE. ¼	51	38
26	N. ½	51	38
34	E. ½ and SW. ¼	51	38
35	All	51	38
36	N. ½ and SW. ¼	51	38
6	N. ½ and SW. ¼	50	38
7	NW. ¼	50	38
1	SE. ¼	50	39
10	S. ½	50	39
11	S. ½	50	39
12	N. ½ and SW. ¼	50	39
13	NW. ¼	50	39
14	N. ½ and SW. ¼	50	39
15	All	50	39
16	E. ½	50	39
21	NE. ¼	50	39
22	NW. ¼	50	39
29	All	50	39
30	All	50	39
31	N. ½	50	39
32	NW. ¼	50	39
25	S. ½	50	40
33	S. ½	50	40
34	S. ½	50	40
35	N. ½	50	40
36	All	50	40
4	N ½	49	40
5	All	49	40
6	All	49	40
7	N. ½	49	40
1	E. ½ and SW. ¼	49	41
2	S. ½	49	41
3	SE. ¼	49	41
10	NE. ¼	49	41
11	N. ½	49	41
12	N. ½	49	41

List of the mineral lands of Isle Royale, Lake Superior land district.

Section.	Part.	Township north.	Range west.
3	N. ½	67	32
4	E. ½	67	32
21	SE. ¼	67	33
22	SW. ¼	67	33
23	S. ½	67	33
24	N. ½ and SW. ¼	67	33
26	N. ½	67	33
27	All	67	33
28	All	67	33
31	All	67	33

List of the mineral lands of Isle Royale—Continued.

Section.	Part.	Township north.	Range west.
32	All	67	33
33	All	67	33
34	All	67	83
35	N. ½	67	33
3	NW. ¼	66	33
4	N. ½ and SW. ¼	66	33
5	All	66	33
6	All	66	33
7	All	66	33
8	N. ½	66	33
18	NW. ¼	66	33
33	SW. ¼	67	34
34	E. ½ and SW. ¼	67	34
35	SW. ¼	67	34
36	SE. ¼	67	34
1	All	66	34
2	All	66	34
3	S. ½	66	34
4	NW. ¼	66	34
5	NE. and SW. quarters	66	34
8	All	66	34
9	All	66	34
10	All	66	34
11	SE. ¼	66	34
12	N. ½ and SW. ¼	66	34
13	All	66	34
14	NW. and SE. quarters	66	34
15	S. ½ and NE. ¼	66	34
16	N. ½	66	34
17	All	66	34
18	All	66	34
20	SE ¼	66	34
21	All	66	34
22	All	66	34
23	W. ½ and NE. ¼	66	34
24	NW. ¼	66	34
26	All	66	34
27	S. ½	66	34
28	All	66	34
29	N. ½ and SE. ¼	66	34
30	S ½ and NE. ¼	66	34
31	NE. and SW. quarters	66	34
33	E. ½	66	34
34	N. ½ and SE. ¼	66	34
35	All	66	34
2	W. ½ and NE. ¼	65	34
3	All	65	34
7	SE. ¼	66	34
8	NW. ¼	65	34
9	All	65	34
10	N. ½ and SW. ¼	65	34
16	NW. ¼	65	34
17	All	65	34
18	All	65	34
19	N. ½ and SW. ¼	65	34
20	NW. ¼	65	34
13	S. ½ and NE. ¼	66	35
22	S. ½	66	35
23	All	66	35
24	N. ½ and SW. ¼	66	35
25	NW. and SE. quarters	66	35
26	NW. ¼	66	35

List of the mineral lands of Isle Royale—Continued.

Section.	Part.	Township north.	Range west.
27	All	66	35
28	All	66	35
29	SE. ¼	66	35
32	E. ½ and SW. ¼	66	35
33	N. ½	66	35
34	E. ½ and SW. ¼	66	35
35	SE. ¼	66	35
36	E. ½ and SW. ¼	66	35
1	All	65	35
2	All	65	35
3	All	65	35
4	E. ½ and SW. ¼	65	35
5	N. ½	65	35
6	E. ½ and SW. ¼	65	35
7	S. ½ and NW. ¼	65	35
8	All	65	35
9	All	65	35
10	S. ½ and NW. ¼	65	35
12	S. ½ and NW. ¼	65	35
13	N. ½ and SE. ¼	65	35
14	N. ½	65	35
15	NW. ¼	65	35
16	All	65	35
17	NE. and SW. quarters	65	35
18	All	66	35
21	NE. ¼	65	35
22	NW. ¼	65	35
24	SE. ¼	65	35
25	N. ½	65	35
26	S. ½ and NE. ¼	65	35
27	All	65	35
28	S. ½	65	35
29	S. ½ and NE. ¼	65	35
31	All	65	35
32	All	65	35
33	N. ½ and SW. ¼	65	35
1	S. ½	65	36
9	S. ½	65	36
10	All	65	36
11	All	65	36
12	N. ½ and SE. ¼	65	36
13	All	65	36
14	NW. and SE. quarters	65	36
15	NE. ¼	65	36
16	N. ½ and SW. ¼	65	36
17	SE. ¼	65	36
19	All	65	36
20	All	65	36
21	S. ½ and NE. ¼	65	36
22	All	65	36
23	N. ½	65	36
24	NW. ¼	65	36
27	SE. ¼	65	36
28	NW. ¼	65	36
29	NE. and SW. quarters	65	36
30	SE. ¼	65	36
31	N. ½ and SW. ¼	65	36
34	NW. ¼	65	36
35	S. ½	65	36
36	All	65	36
2	NW. ¼	64	36
3	N. ½ and SW. ¼	64	36

List of the mineral lands of Isle Royale—Continued.

Section.	Part.	Township north.	Range west.
4	S. ½	64	36
7	SE. ¼	64	36
8	S. ½ and NE. ¼	64	36
9	NW. ¼	64	36
18	N. ½	64	36
23	SE. ¼	65	37
24	NE. and SW. quarters	65	37
25	N. ½	65	37
26	S. ½ and NW. ¼	65	37
27	NE. and SW. quarters	65	37
28	SE ¼	65	37
31	SE. ¼	65	37
32	NE. and SW. quarters	65	37
33	S. ½ and NW. ¼	65	37
34	N. ½ and SW. ¼	65	37
36	SE. ¼	65	37
1	SW. ¼	64	37
4	S. ½	64	37
5	N. ½	64	37
6	NW. ¼	64	37
8	SE. ¼	64	37
9	S. ½ and NE. ¼	64	37
10	N. ½	64	37
17	N. ½ and SW. ¼	64	37
18	S. ½ and NE. ¼	64	37
19	N. ½ and SE. ¼	64	37
20	W. ½	64	37
1	All	64	38
2	SE. ¼	64	38
10	S. ½ and NE. ¼	64	38
11	N. ½	64	38
14	NW. ¼	64	38
15	NE. and SW. quarters	64	38
16	N. ½ and SE. ¼	64	38
17	S. ½	64	38
19	S. ½ and NE. ¼	64	38
20	All	64	38
21	NW. and SE. quarters	64	38
23	SE. and NW. quarters	64	38
24	S. ½	64	38
25	S. ½ and NE. ¼	64	38
26	S. ½ and NE. ¼	64	38
27	N. ½	64	38
28	S. ½ and NE. ¼	64	38
30	S. ½ and NW. ¼	64	38
31	SE. ¼	64	38
32	N. ½ and SW. ¼	64	38
34	NE. ¼	64	38
35	NW. ¼	64	38
6	NW. ¼	63	38
24	SE. ¼	64	39
25	S. ½ and NE. ¼	64	39
26	SE. ¼	64	39
35	E. ½	64	39
36	All	64	39
1	N. ½	63	39
2	N. ½	63	39
9	SW. ¼	63	39
10	All	63	39
11	SW. ¼	63	39

CHAPTER IV.

STRATIFIED AND SEDIMENTARY ROCKS.

Classification of the sedimentary rocks.—Conglomerate.—External characters.—Imbedded fragments of a jaspery rock.—Range and extent.—Keweenaw Point —Veins.—Attempts at mining.—Porcupine mountains.—Montreal river.—Section of the rocks.—Mining in Conglomerate.—Divisional planes.—Sandstone.—Range and extent.—Compact or lower magnesian limestone.—Range and extent.—Organic remains.—Résumé.

Having attempted, with some degree of minuteness, in the preceding chapter, to set forth the boundaries, range, extent, and peculiarities of the igneous rocks of the copper region, it now remains to describe the associated sedimentary rocks, which may be regarded as nearly contemporaneous.

These may be comprised under three divisions, to which are appended the equivalents in the New York classification:

I. *Conglomerate.*—Not strictly a sedimentary rock, but a volcanic tuff.
II. *Inferior sandstone.*—Potsdam sandstone.
III. *Compact or lower magnesian limestone.*—Calciferous sandstone, Chazy limestone, Bird's-eye and Black river limestone.

I. *Conglomerate—external characters.*—The conglomerate of Keweenaw Point and Isle Royale consists of rounded pebbles of trap, almost invariably of the variety known as amygdaloid, derived probably from the contemporaneous lavas, and rounded fragments of a jaspery rock which may have been a metamorphosed sandstone, the whole cemented by a dark-red iron sand. This cement may be regarded as a mixture of volcanic ash and arenaceous particles, the latter having been derived from the sandstone then in the progress of accumulation. It is not unusual to meet with strata composed entirely of arenaceous particles associated with the conglomerate beds; and where these expand to a considerable thickness, the associated sandstone appears in alternating bands of white and red, and exhibits few traces of metamorphism; but where the belts of sedimentary rock are thin, and come in contact with the trappean rocks, the sandstone is converted into a jaspery rock, traversed by divisional planes, and breaking with a conchoidal fracture

The trappean pebbles often attain a magnitude of eighteen inches in diameter. Their surfaces do not present that smooth, polished appearance which results from the attrition of water; in fact, a close observer can readily distinguish between those which have been recently detatched from the rock and those which have been for a time exposed to the recent action of the surf.

The conglomerate appears to have been formed too rapidly to suppose that the masses were detached and rounded by the action of waves and currents, and deposited with silt and sand on the floor of the ancient ocean; for, while the contemporaneous sandstone remote from the line of

volcanic foci does not exceed three hundred or four hundred feet in thickness, the united thickness of the conglomerate bands in the vicinity of the trappean range on Keweenaw Point exceeds five thousand feet. As we recede for a few miles from the line of the volcanic fissure, these amygdaloid pebbles disappear, and are replaced by arenaceous and argillaceous particles. We are, therefore, disposed to adopt the theory, as to the origin of such masses, first suggested by Von Buch:* "When basaltic islands and trachytic rocks rise on fissures, friction of the elevated rock against the walls of the fissures causes the elevated rock to be enclosed by conglomerates composed of its own matter. The granules composing the sandstones of many formations have been separated rather by friction against the erupted volcanic rock than destroyed by the erosive force of a neighboring sea. The existence of these friction conglomerates, which are met with in enormous masses in both hemispheres, testifies the intensity of the force with which the erupted rocks have been propelled from the interior through the earth's crust. The detritus has suddenly been taken up by the waters, which have then deposited it in the strata which it still covers."

Those pebbles, having a highly vesicular structure may have been ejected through the fissures, in the form of scoriæ, while in a plastic state, and have received their rounded shape from having been projected through water—on the same principle as melted lead, when dropped from an elevation, assumes a globular form.†

In the jaspery fragments included in the conglomerate, we often observe a structure analogous to the woody fibre of trees. These fragments (plate, fig. 2) are composed of laminæ, more or less contorted, and furrowed longitudinally, like the markings in the extinct plants of the genus *sigillaria*. A series of striæ, as fine as the engraver's lines, run parallel with the larger ones. These can be traced on some of the specimens, and generally extend through the different folds; while others possess a structure like the cellular tissue of wood. We have no confidence in the vegetable origin of these markings; nor have we any theory to offer in explanation.

While there are no beds of calcareous rocks associated with this group, we have evidence that the waters during this epoch were abundantly charged with lime; for we find this substance, in the form of calc-spar, filling the vesicles of the amygdaloid and the fissures and pores in the conglomerate. It did not result from deposition, but appears to have been forced into the interstices while in a heated condition, and perhaps in a state of gaseous sublimation.

We know that modern volcanoes evolve vast quantities of gases which are capable of dissolving various earthy substances; and is it not reasonable to suppose that the same phenomena were exhibited in the early history of our planet, and on a grander scale, when the communications with the interior were more numerous and extended, and when the recurrence of earthquake shocks and volcanic eruptions was more frequent

*Geognost. Briefe, s. 75—82.

†The extinct volcanoes of Auvergne afford numerous specimens of volcanic *bombs*, which appear to have been ejected in a soft state, and, on cooling in the air, assumed the form of drops or elongated spheroids.

We ought, therefore, *à priori*, to expect to find the products of these gaseous emanations in the vicinity of the volcanic foci.

Range and extent—mineral contents.—In describing the trappean rocks, we necessarily spoke of the associated bands of conglomerate, and the influence they exerted on the productiveness of veins. We deem it unnecessary to enumerate all of the bands, inasmuch as they are indicated on the accompanying maps.

They are lentiform masses, variable in number and thickness. On Keweenaw Point they are numerous, and possess much regularity, ranging with the trap, and dipping to the N. and NW. at angles varying from 20° to 50°. In the Ontonagon district they are less numerous, but near the Montreal river they expand to an enormous thickness.

On Isle Royale they occur under similar conditions with those observed on Keweenaw Point, with this exception, that the dip is reversed—varying from 20° to 40° to the SE. and SSE.

Manitou island is composed of conglomerate, except a few jutting points on the southern coast, which belong to the northern band of trap. Crossing the channel, which is about three miles in width, we meet with this belt on the northeastern extremity of Keweenaw Point, and thence it is protracted west for about sixteen miles, when it becomes lost in the lake. For a greater portion of this distance it serves as a sea-wall; but in a few places the water has broken through and excavated long and narrow harbors in the more yielding trap. The appended sketch of Horse-shoe Harbor will serve to convey an idea of the appearance of this rock. It occurs in long lines, with rounded contours, and is traversed by heavy fissures, filled with calc-spar.

A short distance west of Horse-shoe Harbor a spar vein intersects the shore, which in places is nine feet in width, and bears N. 5° E. It affords an excellent material for lime, and has been calcined for that purpose. On this a shaft was sunk near the junction of the trap and conglomerate, but no indications of copper were disclosed.

On Hays's Point another spar vein, four feet in thickness, and bearing N. 9° E., is seen. The matrix is more or less colored with green and blue silicate of copper, forming the "green rock" of the old voyageurs. Several shafts were sunk upon it in the early days of copper-mining, but the ore was too meagre to be profitable. This vein undoubtedly extends through the intervening trap, and is developed in the second belt of conglomerate near Fort Wilkins, forming what is known as the Black Oxide Vein.

The junction between the trap and conglomerate is well displayed in the vicinity of Copper Harbor. The rocks bear nearly due west, with a northerly dip of 35°. The trap on the upper surface resembles pumice, the vesicles frequently empty, but oftener filled with calc-spar, agates, chlorite, &c. Other portions are wrinkled, as though arrested while flowing. The lower portion of the conglomerate does not exhibit a clear and well-defined line of demarcation, but encloses angular masses of amygdaloid, as though the materials had been thrown down while the trap was in a viscid state. This appearance was particularly noticed a few hundred yards above Porter's island, where the pebbles, for the distance of twenty feet perpendicular, are enclosed in a scoriaceous mass.

Between Copper Harbor and Agate Harbor numerous veins, cutting the formation at nearly right angles, are observed. The matrix for the

most part consists of calc-spar, but occasionally sulphate of baryta is present. Many of them have been explored, and from one, on the southwest quarter of section 28, township 59, range 29, a mass of native copper weighing about 600 lbs. was taken.

At Agate Harbor the New York and Lake Superior Company sank two shafts to the respective depths of 70 and 90 feet, and nearly completed the communication between them by a gallery. The matrix of the vein consisted of calc-spar and sulphate of baryta, with black sulphuret of copper, but not in sufficient abundance to authorize further operations.

This belt forms the outer reef at Agate Harbor, and does not again approach the shore.

Another belt of conglomerate starts from the extremity of Keweenaw Point, opposite Manitou island, and conforms in direction to the one last described, from which it is separated by a sheet of igneous rock about 1,800 feet in thickness. This is known as the main conglomerate range. In places it rises to the height of 650 feet, and expands to a thickness of 4,000 feet. The culminating points in the range are back of Horse-shoe Harbor and Grand Marais. It intersects the coast at Sand bay, and prescribes its form as far as the Lake-shore location, section 33, township 58, range 32, when it bends inland and is prolonged towards Portage lake in a narrow band, which is obscurely traced. It does not differ in lithological character from the belt previously described.

The appended sketch, taken from Fort Wilkins, looking eastward, will convey a correct idea of the contour of the hills. The gentle slope towards the lake corresponds very nearly with the line of inclination, while the precipitous escarpments on the south may have resulted from powerful fissures, which destroyed the continuity of the strata.

This belt, like the former one, contains numerous traces of copper. In preparing the ground where Fort Wilkins now stands, the soldiers came across numerous boulders of black oxide of copper, varying in weight from an ounce to several hundred pounds. Subsequently a vein was dicovered a few rods east of the fort, from fifteen to twenty inches in width, bearing N. 7° E., and corresponding very nearly in direction and position to that before described as occurring in the northern belt on Hays's Point. The gangue consisted of calc-spar, analcime, laumonite, and occasional crystals of fluor-spar, associated with which were the green and blue silicates and the black oxide of copper. This tract had been *located* by the Pittsburg and Boston Company, and was the *first* location made after the extinguishment of the Indian title in 1843. They may, therefore, be regarded as the pioneers in mining enterprise.

A part of their mining force was directed to the exploration of this vein. It was found, near the surface, to consist of the black oxide of copper of surpassing richness, yielding from 60 to 70 per cent. Two shafts were sunk about 100 feet apart, and the black oxide found in both, but, at the depth of fifteen feet, it became exhausted. The fissure and veinstone continued, which induced the company to prosecute further workings, in the hope that the mineral would reappear. Accordingly, the main shaft was extended to the depth of 120 feet, and levels driven in either direction, on the course of the vein, until it became manifest that it was unwise to proceed further.* The aggregate expenditures at this

* Report of the trustees, (1849.)

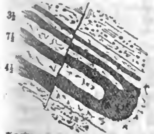
place and on Hays's Point were $25,000. The nett proceeds of the copper raised, $2,968 70. This is the only occurrence of these varieties of copper ore in the district.

At Eagle Harbor a narrow vein of black sulphuret of copper was explored to some extent.

Thin veins of this ore were also observed on the Hitz location, a few miles above the mouth of Eagle river, by the lake shore.

In this range of conglomerate, a few rods from the outlet of Manganese lake, (section 5, township 58, range 28,) occurs a vein of black oxide of manganese, associated with calc-spar. The vein is about 3 feet wide, 15 inches of which is occupied by the ore. It is so highly silicious as to impair its value for working. The inclination of the strata at this point is 25° to the NW., which corresponds with the course of the vein. The following section represents the position of the vein, and the manner of association. The shaded portions are manganese; the light, calc-spar. The inclination is so great that it soon passes beneath the surface.

Fig. 12.



Between Portage lake and the Ontanagon river, the conglomerate does not expand to the enormous thickness observed on Kewecnaw Point. Limited belts are occasionally seen, but cannot be traced continuously for any considerable distance. We observed quite a mass flanking the trap on section 14, township 51, range 38, bearing north, 78° east, and dipping north 50°. A belt, which continues for some miles, is observed south of the Algonquin and Douglass Houghton Company's works, and another occupies the northern flank of the trap in the vicinity of the Ontonagon river, and can be traced for many miles on either side. Lenticular beds are also of frequent occurrence in the trappean rocks, some of which attain a thickness of one hundred feet. Examples of this kind are seen at the Minnesota works, and to the east and west of the river.

At the base of the Porcupine mountains, the conglomerate and associated sandstone expand to a great thickness, and, in the character of the pebbles, afford evidence of having been made up of the ruins of the adjacent igneous rocks. Numerous intercalations of this rock are observed in the trap, differing in no respects from those described as occurring on Keweenaw Point.

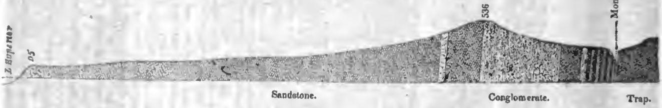
In following up the Presqu'isle river, the black slaty sandstone is observed to be replaced by conglomerate, expanding to a thickness of several hundred feet. To this succeeds the bedded trap, followed by other bands of conglomerate.

In the region of the Montreal river, however, the conglomerate expands to a great width, attaining a thickness of nearly 2,000 feet. The boulders are, in some cases, fully three feet in diameter, consisting mostly of porphyritic trappean rocks and hornblende, cemented by a calcareous paste. This conglomerate bed rises, at its highest point 536 feet.

The annexed is a section of the rocks from the mouth of Montreal river across to the trappean rocks, a distance of about three miles. There are several alternations here of amygdaloidal trap and sandstone. The latter

is generally shaly, and soon crumbles by the influence of atmospheric agencies. These alternations are finely exposed in the bed of the river, which has cut a deep gorge for some distance nearly parallel with the course of the beds. The falls of this river, which have been before noticed, are caused by the unequal wearing of the beds of trap and sandstone, and are highly picturesque. The width of the intercalated beds of shaly sandstone varies from fifteen to nearly one hundred feet. They alternate with beds of trap of nearly equal thickness. The depth of the gorge varies from one hundred to one hundred and fifty feet.

Fig. 13.



Section from the mouth of Montreal river to the trap.

An attempt at mining was made in the conglomerate on section 18, township 50, range 40, a few miles west of the Ontonagon, by the Mendenhall Mining Company; and we are informed that not less than $10,000 were expended on the undertaking. At the time of our visit, it was abandoned. Several shafts, one of which reached to the depth of 100 feet, had been sunk, and galleries run from one to the other; the whole of which were filled with water. The bearing of the vein is north 17° west and may be observed cropping out in the bed of a small stream called Mineral creek, which crosses the location. The gangue is calcareous spar and sulphate of baryta, in which the gray sulphuret of copper occurs in very variable quantities, intermixed with silica. The vein varies in width; sometimes it is split into numerous threads, and again it disappears altogether. Some of the specimens of solid ore were from four to five inches in width, and we were informed that but a few barrels of this had been obtained. That lying about the shafts was very meagre, being mostly spar, mixed with conglomerate, and containing a small per centage of copper. We were informed that the deepest shaft had been carried down below where the ore was found in the vein. Here the vein pitched to the west, with a gradually increased angle, and was underlaid by sandstone. Proceeding southwardly, it became poorer, and the shaft sunk a few rods south of the main one, after having reached a few feet, was in barren rock. The veinstone was, at this point, composed of a curious mixture of imperfect agate and calc-spar, in altered sandstone. Efforts were made to trace the vein into the trap, which is contiguous, but without success. Both carbonate of lime and sulphate of baryta are here found in finely crystallized specimens. The former occurs in hemitropic crystals of considerable interest to the crystallographer. They are a combination of the scalene triangular dodecahedron, of a form hitherto found at only one locality in Siberia; also, in six-sided prisms. Some of the varieties of agate were very beautiful, and it is to be regretted that good suites could not have been secured for the government collection.

The mining operations here have thrown considerable light on the occurrence of copper in the detrital rocks, and demonstrated that these veins are not reliable ones.

We have, in another chapter, described the numerous alternations of trap and conglomerate which occur along the northern slope of the trappean range. Along the southern slope these belts are very rare. Where the Bohemian range breaks through the incumbent rocks at Lac la Belle, a thin band of conglomerate, not exceeding 30 feet in thickness, is observed, which has been traced, at intervals, for two or three miles. Its inclination is 80° to the south and southeast. Regarding these conglomerates, lying north of the anticlinal axis, as composed, in the main, of igneous products, and the sandstones, on the south, as purely detrital accumulations, we are led to infer that, while the region north of the anticlinal axis was subject to a series of volcanic outbreaks, that to the south remained comparatively tranquil.

Divisional planes.—The conglomerate rocks—and the same remarks are applicable to the sandstones—are traversed by different systems of divisional planes, which are found to preserve a remarkable degree of uniformity, giving to the mass a crystalliform appearance. They pursue straight lines, without any deviation, and extend to unknown depths; and so sudden was the shock by which these fissures were formed, that the

intervening pebbles are cut in twain. The main fissures pursue a course varying but a few degrees from the true magnetic meridian, which is found to be the case in other countries. The rocks traversed by these fissures often exhibit not only a vertical, but horizontal dislocation. To convey an idea of their direction and uniformity, we submit the following observations taken with great care by Mr. Hill:

MAIN FISSURES,

Commencing at the western extremity of the point north of Agate Harbor, and thence running east.

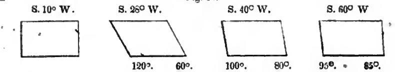
Links.	Course.	Dip.
0....	North, 12 degrees east	East.
20....	North, 10 degrees east	East.
25....	North, 8 degrees east	East.
32....	North, 10 degrees east	East.
68....	North, 10 degrees east	East.
81....	North, 13 degrees east	East.
90....	North, 18 degrees east	+
182....	North, 12 degrees east	East 74 degrees.
250....	North, 8 degrees east	East.
300....	North	East.
310....	North, 8 degrees east	East.
420....	North	East.
525....	North	East.
720....	Northeast	Southeast 45 degrees.
820....	North, 10 degrees east	East.
850....	North, 5 degrees east	+
975....	Northeast	East.
1233....	North	East 80 degrees.
1275....	North, 13 degrees east	East.
1380....	North, 20 degrees east	East.
1500....	North	East.
1550....	North, 10 degrees west	+
1610....	North	—
1650....	North, 45 degrees east	Southeast.
1750....	North	East.

CROSS-FRACTURES.

Course.	Dip.
East	South 70 degrees.
East	South 72 degrees.
South, 80 degrees east	South.
South, 20 degrees east.	
South, 20 degrees east.	

Near Salmon Trout river, the sandstone exhibited several sets of fractures—one set bearing north, another north 60° east, another north 60° west, and another north 40° east. Several of the blocks formed by the lines of division were measured. The following figures represent their forms:

Fig. 14.



At Siskawit bay, Isle Royale, two sets of fissures were observed in the sandstone—one bearing south and southeast, the other south 40° and 60° west.

A further detail of observations on this head is deemed unnecessary, as they all go to prove the general principles before announced.

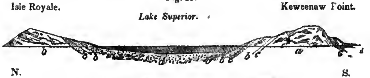
Although the conglomerate attains a thickness of five thousand feet, yet it by no means follows that the ancient sea in which it was deposited extended to that depth. Ripple-marks and clay-cracks have been observed in the upper portions of this group; the one indicates comparatively shoal water,* and the other the ebbing and flowing of a tide, or a change in the level of the water.

The inference, therefore, is, that during the deposition of the conglomerate, the bed of the sea was subject to repeated elevations and depressions, caused by volcanic action, and that its waters obeyed the same tidal laws which govern the existing oceans.

These conglomerates, then, may be regarded as local deposites, formed along the courses of the volcanic fissures by the joint agency of fire and water. When the former causes operated with intensity, the materials consisted of spherical masses of lava and scoriæ. When they acted feebly, or were quiescent, the materials became argillaceous or arenaceous.

Sandstone.—It is not our purpose in this report to set forth the boundaries of the sandstone, much less to describe its characters, where it comes in contact with the pre-existing rocks. These descriptions will be reserved for the general report on the palæozoic rocks of this district. We propose simply, at this time, to show its connexion with the cupriferous rocks before described. In order that this connexion may be better understood, we introduce the following diagram:

Fig. 15.



a. a. Crystalline trap. *c. c.* Conglomerate.
b. b. Bedded trap. *d. d.* Sandstone.

*De la Beche states that the surface-action of the ocean does not affect the bottom beyond the depth of ninety feet. Divers are said to find the water still at that depth during a tempest. Stevenson, however, asserts that the agitations of the sea reach to the depth of two hundred feet.

We have seen that, during the deposition of the sandstone, numerous sheets of trap were ejected, and flowed like lava-streams; and that the igneous and aqueous products were so intermingled as to present the appearance of having been derived from a common origin; and that subsequently the unbedded trap broke through these parallel fissures, lifting up the sandstones, conglomerates, and bedded traps, and causing the whole mass to dip at high angles. Thus, this portion of the bed of Lake Superior is due to these two lines of upheaval. The sandstone between the two lines performs an immense curve, portions of which are at least 800 feet below the chord formed by the surface of the water. The sandstone is seen on Isle Royale, forming the outer reefs of Siskawit bay. It is of a dark-red color, somewhat fissile, and traversed by numerous divisional planes. Thin beds of conglomerate, composed of trappean pebbles, are seen, the whole dipping to the southeast about 8°. This is not a purely silicious rock, but takes into its composition argillaceous particles, with an admixture of oxide of iron. Passing over to the southern shore, the sandstone is first seen on Keweenaw Point, in low reefs, near the Lake-shore location, (section 1, township 57, range 33,) beyond which point, proceeding eastward, it is succeeded by the conglomerate, which rests beneath it. Proceeding westerly, the trap recedes from the shore, and the intervening space is occupied by the sandstone, forming a belt about ten miles in width.

About a mile above the Portage, a good opportunity is afforded for examination. Here commence a series of bold cliffs, which line the coast for several miles. They are composed of strata of unequal thickness and induration. Some of the strata consist of silex, with thin plates of mica interspersed, while others contain portions of alumine, colored red by oxide of iron. The silicious strata afford excellent building materials, and the supply is inexhaustible. Slabs varying from two inches to two feet in thickness, and exposing perfectly level surfaces of forty or fifty superficial feet, can readily be procured. The rock is sufficiently indurated to give it strength, and is little affected by atmospheric agents. The water is of sufficient depth to permit vessels to approach within a few rods of the shore.

The unequal resistance which the strata oppose to the action of the surf has caused the cliffs to assume various fantastic shapes. The harder beds project like cornices, and can be traced almost as far the eye can reach. In the softer materials, the waves have scooped out numerous caverns, resembling gothic doorways. The nearly horizontal stratification of the rocks, their brick-red color, with occasional bands of a lighter tint, and the numerous vertical fissures by which they are intersected, cause them to resemble immense walls of masonry piled up by the hand of man.

These cliffs do not range in continuous lines, but exhibit numerous projections and recessions. Peaks shoot up above the mass, like towers, connected by walls, which at the base are excavated into arches and gateways. The whole is crowned by a dense mass of foliage of the birch, the mountain ash, the fir, and the spruce. From this mass issue numerous fountains, which precipitate themselves for fifty or sixty feet before they mingle with the lake. These cliffs may be regarded as a miniature representation of the Pictured Rocks.

As we recede from the trap, the dip of the sandstone diminishes rap-

idly, and, at the distance of a few miles, the stratification becomes horizontal. The following observations are adduced:

Section 11	Township 57	Range 33	Bearing N. 30° E.	Dip 32°	NNW.
" 33	" 57	" 33	" N. 15° E.	" 20°	"
" 6	" 56	" 33	" N. 15° E.	" 19°	"
" 29	" 34	" 33	" N. 25° E.	" 10°	"
" 9	" 54	" 34	" NNE.	" 5°	"

The average width of this belt from this last-mentioned point westward is nearly ten miles, and continues to range 42, where it is intersected by the Porcupine mountains. Its junction with the trap on the north is rarely seen, in consequence of the drift which reposes on it. It nowhere rises into ridges, but slopes gradually from the trappean chain, and appears to have remained undisturbed since the upheaval of the trap, if we except that general elevatory movement by which the whole district has been raised above the ocean-level.

By the lake shore, (section 33, township 57, range 33,) a singular bed of sandstone is exposed for a distance of eighty rods; and the same has been recognised inland. It is composed of sub-crystalline particles of quartz and feldspar, but the original granular structure, on close inspection, can be recognised. Its bearing and inclination are conformable to the adjacent beds, being north 22½° east, dip 26° north-northwest. From the Portage to the Montreal river, the sandstone is exposed along the lake shore at short intervals. The further it is observed from the trappean rocks, not only does its inclination become less, but the strata are less colored, and the cohesion between the particles is slighter.

Between Salmon Trout and Misery rivers the inclination is very slight, not exceeding 5° to the northwest. The trap range between these two rivers is about six miles inland, and consists of low dome-shaped knobs. To the west it is more prominently developed, and the sandstone in the vicinity acquires a sharper dip, which gradually increases until, at the base of the Porcupine mountains, where the trap approaches within a mile of the lake shore, rising up in a lofty ridge more than a thousand feet in height, the sandstone is tilted up at an angle of 30° or 40°. The intercalated beds in this vicinity are found to present a nearly uniform dip, showing that their elevation is due to a single upheaval.

At Iron river, and at several other points, the sandstone is very fissile and of a dark-brown color, resembling a slaty rock. This rock is observed to dip in a direction different from the general dip of the sandstone which lines the coast. This diversity nas been occasioned by the upheaval of the Porcupine mountains, whose prolongation is at nearly right angles with the general direction of the trap range. The bearing of the sandstone exposed in the bed of the stream varies from north and south to north 40° east and south 40° west.

The Presqu'isle river, a short distance above its mouth, is precipitated 40 feet over the dark-colored slaty sandstone. It here dips 10° northwardly, the bearing being south 61° west. About one-half of a mile from its junction with the trap, it bears north 8° west, and dips north-northwest 30°. At the mouth of Black river the same form of sandstone appears, and may be regarded as an accidental variety of the rock which lines nearly the entire coast.

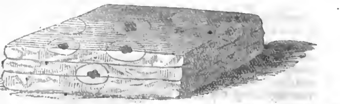
Advancing along the coast towards the Montreal river, the inclina-

tion of the sandstone gradually increases, and at the latter point it is observed in a nearly vertical position. It is here about two miles removed from the trap, and has the same inclination as at the point of contact. These dips have been taken on the northern slope of the trap range by the lake shore, or in the beds of streams where there was a good exposure of the rock. South of the trap range, the sandstone is almost invariably horizontally stratified, except in the immediate vicinity of the trap, where, for the most part, it dips at a high angle to the south. Judge Burt, however, found the sandstone south of Porcupine mountains dipping to the north. The general relations of the sandstone and trap will be better understood by referring to the subjoined section from Lake Superior, in township 51, range 43, to the Ontonagon river, in township 49, range 41.—(see opposite page.)

Passing over the trappean ranges, we find the sandstone occupying the southern slope, and bearing the same relation to the trap as the northern belt, with this exception, that the intervening masses of conglomerate are, in the main, wanting. On the south side of Keweenaw Point, (section 27, township 58, range 28,) above Bète Gris bay, the sandstone is seen bearing north $22\frac{1}{4}^{\circ}$ east, and dipping southeast, or away from the trap, at an angle of 78°, and can be traced along the lake shore for three-fourths of a mile. It is nearly white in color, composed almost entirely of silicious particles, and would form an excellent firestone. On section 36, township 58, range 29, it is again exposed, flanking a thin band of conglomerate. It here consists of alternating bands of a white and red color, having a high inclination. In the bottom of the bay, when the lake is tranquil, these bands can be seen describing immense curves, conforming in direction to the course of the Bohemian range. This is a point of much interest, as it enables us to solve the problem of the relative ages of the unbedded and sheet trap, and of the associated sandstone and conglomerate. Their order of succession is here distinctly traced.

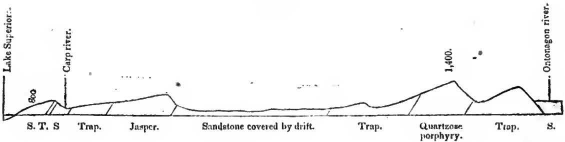
On the east side of section 14, township 57, range 29, the sandstone is observed in low ledges, forming the southern coast of Bète Gris bay. Although but a few miles removed from the igneous rocks, it reposes in a nearly horizontal position. The rock is very fissile, of a deep red color, and contains patches of dove-colored clay and ochre, or hydrous peroxide of iron. There are also numerous concretions, resembling, at first sight, the vertebræ or joints of crinoids, the mould being filled with pure white silex, while in the centre it is not unusual to see a dark speck corresponding with the alimentary cavity or internal canal. These concretions are so curious that we append a figure. Cutting through one of them at right

Fig. 17.



angles with the planes of stratification, it is found to be a sphere or ball

Fig. 16.



Section from Lake Superior to the Ontonagon river across the Porcupine mountains.

enveloping the black speck which served as a nucleus. This peculiarity in the sandstone has been noticed at frequent intervals as far east as the Pictured Rocks, and even at the outlet of the lake, though at the latter place less perfectly developed.

At Tobacco river the sandstone is finely displayed in alternating bands of white and red, forming cliffs fifty or sixty feet in height. Just before its entrance into the lake, the stream is precipitated over a ledge of this rock from a height of ten feet. The aboriginal name of the river is *Wa-sakodewabikag-sepi*, or Burnt Stone river, from the prevailing tint of the rock. The present name applies to the dark color of the water furnished by the cedar swamps which skirt the base of the Bohemian mountains. Along the shore the sandstone is beautifully variegated—parallel bands of a flesh-red color crossing the mass without reference to stratification, and forming a striking contrast with the buff color which constitutes the prevailing tint. (Plate XII, fig. 1, *retro*.)

Proceeding up Keweenaw bay, we find the sandstone lining the shores in bold cliffs, with occasional entering bays; but there are places where for miles it is impossible to find a boat-harbor. The stratification is horizontal, or rather consists of numerous gentle undulations. The waves have excavated caverns in the cliffs, and fashioned them into many grotesque forms. The prevailing dip of the sandstone, we inferred, was about 5° to the northwest. At one or two points we noticed that the strata had undergone slight vertical dislocations. As we approach L'Anse, the dip to the northwest becomes apparent, and a change in the external characters is noted. The grains become coarser, and pebbles of white quartz are disseminated through the mass. We rarely meet with a pebble of greenstone or amygdaloid. At Crebbesa's (section 25, township 51, range 33) it bears northeast, with a very perceptible dip to the northwest.

We have thus traced it to the limits of the metamorphic rocks. To describe its relations to this system, although it forms one of the most interesting features in the geology of the region, does not come within the purview of this report.

The Sturgeon river was explored by Mr. Hill. For twenty miles no rock was exposed in place, and its banks are bordered with stratified deposites of clay, sand, and gravel. On section 8, township 51, range 34, angular blocks of sandstone are observed, and in the southwest quarter of the section the white and red variety is exposed in the bed of a small stream. It is extremely friable, and in other respects resembles that which is exposed at the White rapids on the Menomonee river, south of the great anticlinal axis between the waters of Michigan and Superior.

Near the south boundary of township 51, range 34, the river flows over a rocky bottom composed of sandstone, dipping northwest from 2° to 2½°. The rapids continue for three miles over this rock. The local disturbances in this vicinity by reason of the proximity of the igneous rocks have been elsewhere described. The sandstone rarely emerges to the surface; but is covered with heavy accumulations of clay. The Sturgeon river at the time of our ascent was at high flood, a condition by no means favorable to geological explorations.

On Torch river the sandstone is exposed in the bed of the stream for the distance of more than a mile. It consists of yellow or red grains, without any visible cement, enclosing quartzose pebbles and patches of dove-colored clay similar to that which occurs at Beté Gris bay.

As this sandstone possesses no economical value, it is deemed unnecessary to incorporate further local details. Its boundaries are defined, to the best of our information, on the accompanying maps.

The sandstone extends uninterruptedly from Bête Gris bay to Black river, a distance of 120 miles. On the west and north it is bounded by the trappean ranges, and on the south by the granite and metamorphic rocks. On Keweenaw Point it is about ten miles in width, but between the head of the bay and Agogebic lake it expands to twice that width. It forms a longitudinal valley, through which sweep the Sturgeon, the Ontonagon, and Black rivers, in a transverse direction. The general appearance of this valley is that of a nearly level plain, covered to a great depth by stratified deposites of reddish-colored clay, in which the streams have excavated deep and narrow ravines. It is thickly wooded, and the soil well adapted to agricultural purposes.

This sandstone has been examined from Fond du Lac to Grand Sâble, a distance of more than 300 miles. While the beds, in the main, have been so little changed in the process of consolidation as to preserve on their surfaces the forms of ripple-marks and clay-cracks as perfectly as we behold them at this day on the borders of the lake, and while even the indentations of the rain-drops which pattered upon that ancient shore are well preserved, we search in vain for any traces of animal or vegetable life which flourished during this epoch.* From their entire absence we are led to infer that, during the deposition of the sandstone, the waters of the sea, either from their high temperature or by reason of their impregnation with noxious gases, or both causes combined, were rendered incapable of sustaining vegetable or animal life.

We have adduced abundant evidence to show that during this epoch the igneous causes were in a state of intense activity—that numerous lava-currents issued from the volcanic fissures, and flowed among the silts and sediments of the ancient sea. Modern volcanoes emit carbonic acid gas, sulphuretted hydrogen and muriatic acid. These products must have been evolved much more copiously during this epoch, when the exterior surface of the earth communicated with the interior by numerous and far-reaching fissures, at that time unfilled.

Humboldt supposes that the abundance of limestone which characterizes the Silurian epoch resulted from the decreasing heat of the superficial waters, allowing them to absorb carbonic acid from the air, at that time overcharged with that element.

Before the sandstone was entirely deposited, the igneous causes had almost ceased to operate. We may suppose that, as the waters parted with their heat, the limestone absorbed carbonic acid, and was thrown down as a precipitate on the floor of the ocean.

In these precipitates, forming the lower magnesian limestone, we detect in the rocks of this region the first traces of organic life. The position of this member of the series, and the entombed remains, we shall now proceed to describe.

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*We might perhaps except the obscure traces of fucoids described by Dr. Locke as occurring at the Pictured Rocks. One or two specimens of *lingulæ* have been found in Tequamenen bay; and on the St. Croix, according to Dr. Owen, where the evidences of volcanic paroxysms are less marked, the sandstone is highly fossiliferous.

COMPACT, OR LOWER MAGNESIAN LIMESTONE.

The sandstone, as we ascend from the lower strata to the higher, is found to be less colored by the oxides of iron, and to take into its composition particles of lime, until finally it passes into well-characterized, compact, magnesian limestone. The upper portions of the sandstone effervesce with acids, where a granular structure only is recognisable by the eye. We apply the term magnesian to this belt to define its lithological characters, although the associated organic remains would seem to indicate the presence of several of the lower Silurian groups, which cannot be recognised by lithological differences.

The whole of the northern slope of the anticlinal axis bears evident marks of having been subjected to extensive denudation; and hence over the greater portion of this region we look in vain for traces of limestone rocks. If they existed, they have been swept away; and wherever we penetrate through the thick deposite of clay and sand, we find the rock in place to be sandstone. A limited patch of limestone, however, yet remains west of L'Anse, forming the highest elevation in that direction till we reach the trap range. It is in township 51, range 35, and occupies a portion of four sections. It was first discovered by Mr. C. C. Douglass, in the summer of 1846, but nothing farther was known until the township was subdivided in 1848, when its extent and exact locality were determined.

Near the quarter-post, between sections 13 and 14, township 51, range 35, the limestone is seen in place, forming a bluff, about 50 feet above a small stream at its base. Here the strata are nearly horizontal, though large blocks have slidden down the side of the hill, and thus appear to dip towards the east. The limestone rests upon a white sandstone, which belongs to the upper part of the formation which we have described as underlying the whole of this valley.

A little to the west of the line, between sections 23 and 24, and extending for a little more than a mile, the limestone is seen in a high cliff which runs south and gradually bends to the eastward, crossing the line, in several ridges, near the southern limit of these sections, when it disappears beneath the drift materials. Ledges of rock are occasionally exposed, from 20 to 50 feet in thickness. The height of the bluff above the surrounding country is fully 200 feet; and about 600 feet above Lake Superior. The limestone is distinctly stratified, in layers from an inch to a foot in thickness, which dip, according to measurements taken along the lower edge of the precipitous portion, from 25° to 30°; and the direction of the dip is always to the eastward, varying at different points from N. 50° E. to S. 20° E.

It is of a buff color—in some places silicious, with quartzose nodules; but in others, highly magnesian, containing about 45 per cent. of carbonate of magnesia.

From the horizontality of the first described deposite, which occurs about a quarter of a mile to the north, it seems evident that the limestone overlies the sandstone, although the position of the inclined beds of the more southerly portion of the limestone is at first difficult to explain, since the surrounding country is low and level, and underlaid by sandstone in horizontal beds. It seems evident that at this

point the country has been disturbed, and upheaved by igneous action beneath, which has raised the strata, without any appearance of trappean rocks on the surface. This view of the case is corroborated by the fact that at no great distance from this point an elevation occurs from which the strata of sandstone dip on all sides, and although there is no igneous rock visible, yet it is evident that the sandstone has been raised in a dome-like protuberance by a mass of igneous rock pressing upon it from below. The same cause is also indicated by the irregular variation of the magnetic needle in the vicinity observed by the linear surveyors, which is unusual except when caused by the proximity of the trappean rocks.

The isolated knob of trap called Silver mountain, which has been before described, is an example in point—where, however, the elevating force has not only been sufficient to raise and shatter the strata of sandstone, but, at the same time, to protrude a mass of molten igneous matter above the surface.

Geological position.—As to the geological position of this limestone, there can be little doubt that it is superior to the sandstone. Mr. Whitney and Mr. Hill have both explored it with care, and both have arrived at the same conclusion. The sandstone, wherever observed in this region, rests unconformably on the argillaceous schists. It is seen in this position ten miles east of this deposite, and is found in the beds of the streams in this vicinity. On the southern side of the axis; Messrs. Foster and Hill found these two groups occupying the same relative position.

Organic remains.—The fossil remains entombed in this deposite are by no means abundant, and are so imperfect, consisting for the most part of casts, that it is impossible to identify species. We have submitted such as were collected by us to Mr. James Hall, the accomplished palæontologist of the New York survey, and herewith append his report:

"I have examined the fossils submitted to me from the limestone west of Keweenaw bay. The specimens, unfortunately, are all in the condition of casts of the interior, and therefore the evidence is less satisfactory than if the shells had been preserved. The evidence from the whole together goes to prove that the rocks from which they were obtained belong to the older Silurian period.

"This evidence I will give in detail, so that you may judge of its value, as well as myself; and you may give what weight you think proper to it in your generalizations.

"One of the most conspicuous fossils (No. 1) is a species of *maclurea*, not unlike the species from the Chazy limestone. All the species of this genus yet known have been found in the rocks of the lower Silurian period; and although many hundreds of gasteropodous molluscs are known in the higher rocks, there is not one of this genus, nor any form approaching it. I feel inclined, therefore, to regard this genus as a lower Silurian type.

"No. 2 is a fragment of a spiral gasteropod, either *murchisonia* or *loxonema;* the surface markings being obliterated, it is not easy to determine to which of these genera it belongs. Its association with *maclurea* is presumptive evidence that it is a *murchisonia*, the species of which in this country are restricted to the lower Silurian rocks.

"Among the acephalous molluscs, the casts of a species of *ambonychia* (No. 3) are very conspicuous. The species are near *A. orbiculata* of the

Trenton limestone, but are somewhat more elongated, and in this respect approach *A. amygdalina.*

"A considerable number of specimens are of species belonging to the genus *modiolopsis,* (No. 4,) among which are several bearing a close resemblance to *M. truncatus.* Other specimens (No. 5) bear a very close resemblance to *edmondia subtruncata* and *E. subangulata* of the Trenton limestone, (Pal. N. Y., vol. 1, p. 156, pl. 35, figs. 2 and 3;) but these specimens, which are casts, show a greater affinity to *modiolopsis* in having the strong anterior muscular impression so characteristic of that genus.

"The specimens No. 6 are casts bearing a very close similarity to *edmondia ventricosa.* (Pal. N. Y., vol. 1, p. 155, pl. 35, fig. 1.) These specimens cannot but be regarded as identical or closely allied to the species cited.

"The cast bears no strong anterior muscular impression, but the laminæ between the beaks are impressed on both sides by prominent teeth, which furnish sufficient marks to identify the species in this condition.

"No. 7 is another species of the same genus as the last, and is very closely allied, if not identical with a species from the Trenton limestone of New York.

"The *leptænæ* (No. 8) have the characters of *L. sericea,* which in its highest range does not extend above the Clinton group of New York, and is more characteristic of the limestone from the base of the Trenton upward to the top of the Hudson river group, or blue limestone of Ohio.

"The species of *orthis* (No. 9) is too obscure to be identified, but it presents the characters known to me only in the lower Silurian rocks.

"The crinoid joints on specimen No. 10 belong to the genus *glyptocrinus.* The species is not more recent than the Hudson river group.

"The fragments of *orthoceratites* are too obscure to form any reliable opinions concerning them. The other fossils belong to bodies unknown to me at the present time."

From all of the facts, these fossils may be regarded as belonging to the earliest types of organic life. From the limited scale on which these deposites are developed, and the imperfect character of the organic remains, it is impossible to fix their precise equivalents in the New York classification. The sandstones and limestones which we have described may be regarded as the equivalents of the Potsdam and Calciferous sandstones, the Chazy, Bird's-eye, and Black river limestones, and perhaps of the Trenton and even the Hudson river groups.

We have designedly omitted many facts with regard to the palæozoic rocks of this region; but in a subsequent report we purpose to describe their range and extent, and also their fossil contents. In the execution of this task we shall be aided by Mr. James Hall, who has investigated the Silurian rocks more thoroughly perhaps than any other American geologist.

RÉSUMÉ.

Having thus, in several of the preceding chapters, delineated the boundaries and described the lithological characters and mineral associations of the different systems of rocks embraced within the copper region, it will

not be deemed inappropriate to advert to the varying conditions of the earth during the period of their formation.

We may suppose that at one time all of this district formed a part of the bed of the primeval ocean. Adopting the theory of a cooling globe, we may further suppose that the waters were in a heated condition, and differed essentially in chemical composition from those of the present oceans. The earth's crust was intersected by numerous, powerful fissures, and the communication between the exterior and interior was unobstructed. Volcanic phenomena were much more frequent, and exerted on a grander scale. Each volcanic paroxysm would give rise to powerful currents and agitations of the water, and their abrading action in detaching portions of the pre-existing rocks, and depositing them in beds and layers on the floor of the ocean, would operate with greater intensity than at the present time. We can trace the remains of one volcanic fissure extending from the head of Keweenaw Point, in a southwesterly direction, to the western limits of the district; and of another, in a parallel direction, from the head of Neepigon bay to the western limits of Isle Royale. Along the lines of these fissures existed numerous volcanic vents, like those observed at this day in Peru, Guatemala, and Java, which were characterized by periods of activity and repose. From these vents were poured forth numerous sheets of trap, which flowed over the sands and clays then in the progress of accumulation. During the throes and convulsions of the mass, portions of rock would become detached, and rounded simply by the effects of attrition, and jets of melted matter be projected as volcanic bombs through the air or water, which, on cooling, would assume spheroidal forms; while other portions of the rock, in a state of minute mechanical division, would be ejected in the form of ashes and sand, which, mingling with the water, would be deposited, as the oscillations subsided, among the sands and pebbles at the bottom of the sea. During the whole of this period of volcanic activity, the sands which now form the base of the Silurian system were in the progress of accumulation, and became mingled with these igneous products. The level of the sea, as evidenced by the ripple-marks, was subject to repeated alterations: sometimes it rose so shoal that the marks of the rippling waves were impressed on the sands; at others, it sank to unfathomable depths.

In the process of consolidation, the rocks became traversed by numerous fissures, and the water, charged with lime, was forced in like jets of steam, filling them with materials different from the enclosing mass. In this way the pores in the conglomerate and the vesicles of the amygdaloid were filled.

Thus alternating bands of igneous and aqueous rocks were formed,* until finally the great crystalline masses of greenstone were protruded through the fissures, not in a liquid, but in a plastic state, lifting up the bedded trap and conglomerate, and causing them to dip at high angles from the axis of elevation. As the volcanic action diminished in energy, the detrital rocks enclosed fewer igneous products; and, when it ceased

* Consult, *passim*, De la Beche, (Survey of Cornwall,) Murchison, (Silurian System,) and Professor Edward Hitchcock, (— vol. American Journal of Science,) as to the mode of formation of the bedded trap.

These belts have often been described as *dikes*, into which the molten matter has been injected along the lines of least resistance. If this were the case, we ought to find them, like the *dikes* of greenstone in the granite, cutting across the formation, for that would be the line of least resistance, and penetrating the mass in numerous ramifying veins. We should expect to find the

altogether, sand and clay, derived from regions remote from the lines of disturbance, were the only materials which, for a time, were deposited on the floor of the ocean.

To illustrate the nature of volcanic action, we need only to revert to instances which have happened within the present century.* So recently as 1831, a mass of rock rose up from the sea near the coast of Sicily, where soundings had previously been made to the depth of six hundred feet. This mass, which was subsequently known as Graham's island, rose gradually from the water, until it attained an elevation of two hundred feet above the surface, and a circumference of three miles. It slowly diminished to the circumference of three hundred yards, and in the course of three months sank eleven feet below the water, leaving a dangerous reef.

The formation of this island was attended with earthquakes and water-spouts, and the effusion of vast quantities of steam and vapor. The surrounding water was covered with scoriæ and the bodies of fishes. Fragments of rock were detached by the waves and currents, and deposited in the bottom of the sea.

Now, if its bed were laid bare, it would probably be found to exhibit a section somewhat like the following:

1. A mass of volcanic rock, forming an axis or cone, crystalline or granular in proportion to the rapidity or slowness with which it parted with its heat, and the degree of pressure to which it had been subjected.

2. Volcanic breccia, consisting of fragments which had become detached and afterwards reunited with the fluid mass.

3. Coarse conglomerate, composed for the most part of pebbles derived from the upheaved mass.

4. Beds of arenaceous and calcareous particles, brought down by the rivers of the adjacent coast, and enveloping the remains of fishes, if not too perishable in their nature, and of shells, inhabiting the surrounding sea.

The conglomerates and trap tuffs would rapidly thin out as we receded from the volcanic focus, and be replaced by the silts and sediments derived from the rivers flowing into the sea.

Such, we conceive, was the process by which the rocks embraced in this report were formed. The heated condition of the fluids, as well as the gaseous exhalations constantly escaping through the open fissures, would prevent the development of animal and vegetable life.

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junction between the igneous and aqueous rocks clear and well defined, and no marked characteristics between the *upper* and *lower* portions of the erupted matter.

This, however, is far from being the case. The *upper* portion of the trap belts is highly vesicular, resembling pumice. Frequently we find angular blocks of trap included in this paste, like ice which has been broken into fragments and afterwards reunited. We find sandstone deposited in the *fissures* of the amygdaloid, and angular fragments of the latter included in the sandstone. Between the two rocks there is no well-defined line of junction. The sand and pebbles appear to have been thrown down while the latter rock was in a viscid state. On the other hand, where the trap is exposed reposing *on* the sandstone, the line of demarcation is clearly defined, the trap is less vesicular, and the sandstone more changed. These appearances clearly indicate to our minds that the bedded trap flowed like lava-streams among the sands while in the progress of accumulation, instead of having been injected in the form of dikes after the consolidation of the strata had been effected.

*This incident is cited by Murchison in his Silurian System, and applied in illustration of the formation of the bedded trap.

When the igneous action became dormant, the water, having parted with a portion of its heat, would absorb carbonic acid from the atmosphere, which, uniting with the lime held in solution, would be precipitated in beds and layers at the bottom of the sea. This Humboldt conjectures to have been the origin of the vast deposites forming the Silurian limestones. As the condition of the water changed, numerous types of animal life sprang into being, whose remains are so profusely scattered throughout the strata of that era.

Note.—Since the foregoing chapter was written we have examined Dana's Geology of the Exploring Expedition, and find that his description of the volcanic belts of the Pacific islands corresponds in many respects with those of the region under consideration.

Thus, Maui, one of the Sandwich islands, is composed of compact and cellular basalt, and compact clinkstone; but at the northeastern extremity there is a cliff of conglomerate 300 or 400 feet high In a pass through the mountains, Dr. Pickering observed it 2000 feet above the level of the sea, consisting of half rounded fragments of volcanic rocks.

"On Oahu, the compact basaltic lava alternates at times with conglomerate and tufas. Many of the conglomerates are beds of rounded stones and gravel, of the same material as the mountains. Others are compacted beds of basaltic earth, and have a tufa character. The material in many places consists of true volcanic scoriæ and cinders; the former twisted and ropy, and the latter looking like cemented pitchstone, and the whole is so loosely aggregated as to crumble in the hands. The alternation of the solid and conglomerate layers may be seen at many places. The latter are very irregular; graduating frequently into the finer kinds, and forming irregular beds."

In describing the geological features of Kawai, another of this group, he remarks: "The conglomerates are very various in structure. Some are a coarse tufa; others consist of large rounded masses—many thirty cubic feet in size, lying together, with earth and pebbles filling up the interstices. They contain all the rocks of the mountains, the most cellular, as well as the most compact. Near the descent into the Harapepe valley, not far from the bottom, there were masses of scoriæ in the conglomerate, looking as if there had been ejections of scoriæ in the vicinity while the island structure was in progress, and before the superincumbent two hundred feet of layers had been formed."

Similar conglomerates occur at the Society islands, and the Samoan islands. "At the Fejee islands the coarse conglomerates pass gradually into a basaltic sandstone, consisting of fine grains of a very uniform texture. A still finer variety of compact structure resembles an argillaceous rock, and might be mistaken for it from hand specimens. * * *

"At the Mali cliffs the conglomerate differs in hardness; but in most instances bears evidence of the action of heat in the firmness with which the fragments are cemented together. They are sometimes found in close contact with the solid basalt, at first seeming to be imbedded in it. At many localities the rock will as readily break across the fragments of basalt as along the material which unites them. These rocks are generally stratified; though the stratified structure is often more distinctly seen in the distant view than on the spot. In some instances it is minutely distinct. The strata are generally horizontal, but along the shores it is not unusual to find a large inclination towards the sea. Some of the higher elevations of Vanua Lebu, (Fejee islands,) consist of these conglomerates. The little village of Mathuata is over-looked by a frowning bluff 2,000 feet in height."

CHAPTER IV.

MINES AND MINING.

The extent and depth of the principal mines.—The effects of a knowledge of metals on civilization.—England, her minerals.—The invention of gunpowder.—The steam engine.—The method of proving veins.—Stopeing.—Timbering.—Machinery for raising the ores.—Detailed description of the Lake Superior mines.—Their present produce and prospect of future increase.—Statistics with regard to the mineral wealth of different countries.—The consumption of copper by different nations.

The exploitation of mines affords some of the most splendid examples of human contrivance and ingenuity. In extent these underground workings surpass the proudest monuments of architecture, and, with their various shafts, adits, and galleries, constitute a labyrinth as inextricable as that of Crete. The largest architectural structures are erected to gratify the public taste, or commemorate some signal achievement in arts or in arms; but these subterranean structures exhibit proofs of elaborate and persevering effort scientifically directed to what is practical and useful.

To show the extent to which they have been carried, a few prominent examples will be cited. The engine-shaft of the United and Consolidated mines in Cornwall reaches to the depth of 1,650 feet; and the length of the various shafts, adits, and galleries exceeds 63 miles. The great adit for the discharge of the waters of the Gwennap mines, Cornwall, exceeds thirty miles.* The depth of the famous silver mine of Valenciana, Mexico, is 1,860 feet. The workings of the Samson mine at Andreasberg, in the Harz, have been prosecuted to the depth of 2,197 feet. The depth of the mines in the Saxon Erzebirge, near Freiburg, are, in Thurmhofer mines 1,944 feet; in Honenbirker mines 1,827 feet. The depth of the celebrated mine of Joachimsthal, in Bohemia, is 2,120 feet. The Eselschacht, at Kuttenberg, in Bohemia, a mine which is now abandoned, reaches the enormous depth of 3,778 feet. At Rörerbühel there were, in the sixteenth century, excavations to the depth of 3,107 feet, and the plans of the works are yet preserved.† These excavations appear the more wonderful when it is considered that they were made before the introduction of gunpowder. The old Kuttenberger mine is an example of the greatest depth to which human labor has been able to penetrate; and if, to use the language of Humboldt, we compare its depth (a depth greater than the height of the Brocken, and only 200 feet less than that of Vesuvius) with the loftiest structures that the hands of man have erected, (with the Pyramid of Cheops, and with the Cathedral of Strasburg,) we find that they stand in the ratio of eight to one.

The products of mines have contributed in a marked degree to the ad-

* De la Beche and Burr.
† Humboldt, Cosmos, volume 1.

vancement of the human race. Without a knowledge of their application to the useful arts, the human family would have remained in the rudest and most simple state of society, dependent on the chase or the spontaneous fruits of the earth for the means of subsistence; or certain tribes, under favorable circumstances, might have become nomadic herdsmen. This knowledge rests at the foundation of the three great objects of human pursuit—agriculture, commerce, and manufactures.

To show how intimately the metals are connected with the comforts and conveniences of life, we need only to refer to our daily observation. They afford to man the means of rapid communication between distant points; they are essential in the construction of the roof that shelters him, in the preparation of the food that nourishes him, and of the raiment wherewith he is clothed.

It will be found, too, that the greatness of a nation is as dependent upon the geological structure of the country as upon any peculiarity of its laws and institutions. England owes her pre-eminence among European nations as much to her mineral wealth as to the principles of her free constitution. It is probable that she would have been as powerful as we now behold her, had she never been successively invaded by Roman, Dane, and Norman. Long before the Christian era, her shores were visited by the Tyrian fleet, in search of tin to convey to the then emporium of the world. Her mineral wealth has been the main-spring of her prosperity; and were this exhausted, she would sink to a second-rate power. It is this which has built her workshops and factories, and filled them with colossal machinery; it is this which has equipped her fleets, and made her the carrier of the world on the great highway of nations. Her exhaustless supply of fossil fuel has made Swansea the smelting-house for the copper of both hemispheres. It is this which moves her 20,000 steam-engines, supplanting the labor of at least five millions of men, and performing it with a precision and certainty which human hands could not attain.

There are two inventions which have given the moderns infinitely greater facilities in the exploration of mines than were enjoyed by the ancients. These are the inventions of gunpowder and the steam-engine.

The invention of the former has been ascribed to the Arabian alchymists, but M. Reinaud has shown that their claim is without foundation. It was first used for blasting rocks in the Rammelsberg mines, in the Harz mountains, in the twelfth century. It was first introduced into England, according to Mr. Watson, early in the seventeenth century, by Prince Rupert, who brought over a gang of German miners and employed them in the copper mines of Staffordshire. It was not known in Somersetshire until 1620, after which it became introduced into Cornwall. It has been supposed that it was first used in the districts of Lelant, Zennor, and St. Ives, by two men, named Bell and Case, who came from the East. They kept their operations a profound secret, suffering no one to see them charge the holes; but a man of Zennor concealed himself behind a bolt, and discovered and revealed the mystery.

The steam-engine has proved as efficient an auxiliary in the working of mines as gunpowder, and without its aid, many of the mines of Europe, now profitable, would be rendered worthless.

The advantages of this agent have been graphically described by Mr.

Webster:* "It is on the rivers, and the boatman may repose on his oars; it is in highways, and begins to exert itself along the courses of land conveyances; it is at the bottom of mines, a thousand feet below the earth's surface; it is in the mill, and in the workshops of the trades; it rows, it pumps, it excavates, it carries, it draws, it lifts, it hammers, it spins, it weaves, it prints."

The first steam-engine employed in mining in Great Britain was erected in Cornwall, between the years 1710 and 1714; now, the steam-power thus employed for these purposes, according to Mr. Watson, may be estimated as amounting to the labor of 150,000 horses, or that of 750,000 men.

In the Lake Superior copper region the position of the mines is generally exceedingly favorable for exploration; they are mostly situated in the lofty trappean cliffs, which afford great facilities for raising the ore and for draining the water.

The usual method resorted to for the purpose of mining a vein, the position, underlie, and bearing of which have been determined, is to sink shafts on the lode where it is nearly vertical, or away from it where it is inclined, so as to intersect it at a given depth. In the latter case, it is necessary to excavate much unprofitable ground in order that the working shaft may be perpendicular. Simultaneously with these operations, it is advisable to commence the construction of an adit-level—a work requiring the exercise of the highest judgment and skill on the part of the mining engineer, not only to select the most advantageous site, but to intersect the shaft at a given point. The adit-level often serves the double purpose of draining the mine and of exploring the country through which it passes. Where a lode is profitable, the adventurers often expend large sums to get rid of a few inches of water. Professor Ansted states that he has often known £20,000 or £30,000 expended in this way for the purpose of saving a single foot of water. We have before adverted to the immense sums expended at the Consolidated mines on these objects.

The contents of the lode are attacked by means of horizontal galleries extending between the shafts. These are ordinarily driven at the depth of 50 or 60 feet. Winces or vertical shafts are often started from the extremities of the galleries, for the purposes of ventilation and laying bare the lode. In this way the metallic contents of a vein are cut into a series of oblong blocks, the removal of which is called *stoping*. This is accomplished in two ways—either from above or below. In either case the excavations are disposed in steps, like a stair. One miner cuts out a rectangular mass from 4 to 6 yards in length and 2 yards high. While he is carrying forward this work, another miner commences two yards beneath the first, and in the same manner excavates the rock beneath his feet. In this manner as many miners operate simultaneously as there are steps between the two horizontal galleries. As they advance, wooden floors are constructed for the purpose of sustaining the attle or rubbish. Such portions of the lode only are taken down as are supposed to be sufficiently rich to pay for the extraction of the metal. This method of working will be readily understood from an inspection of the sections of the mines attached to the descriptions in this chapter.

The ascent and descent of the miners is effected by means of ladders placed against the shaft, interrupted at every ten fathoms by floors. In-

* Address before the Boston Lyceum.

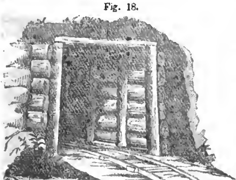
ventions for ascending and descending by machinery have been put in practice in the deep mines of the Harz, and other districts where the mines have been worked to a great depth, by which a great saving of time is effected.

The timbering of the shafts and adits forms in many mines a very considerable item of expense. In Cornwall, the timber mostly employed is Norwegian pine; in Germany, on the contrary, oak is chiefly used. Such kinds of wood as can be had at the least cost are generally used, though the importance of sound timbering in extensive mines is very great, and the condition of this portion of the work forms a considerable item in estimating the value of a mine which has been long worked. The quantity of timber in the Cornish mines is so great that it has been estimated that it would require one hundred and forty square miles of Norwegian forest to supply it.

The quantity of timbering required in the Lake Superior mines is comparatively small, since the walls of the shafts are of firm and unyielding rock; but near the surface, where the rock is broken and disintegrated, strong supports are requisite.

The annexed sketch (fig. 18) will explain the method of timbering a horizontal excavation through which a tram-road is laid for conveying the ores to the surface:

Fig. 18.



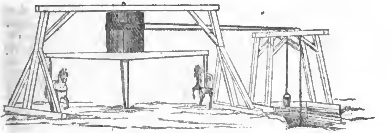
In the Lake Superior land district, the resinous trees afford the best material for timbering; and the tamarack, in strength and durability, will probably be found superior to all others. The spars should be deprived of their bark, as, by retaining the moisture, it accelerates decomposition.

The pumping of the water from the mines, and the raising of the ore, in this district, have been thus far effected principally by horse-whims. At the Cliff mine it was the intention of the proprietors to put up steam machinery for this purpose during the past winter, which we presume is now in successful operation.

This agency will ultimately be employed at all the mines, even where water-power can be made available; for, in a region where the climate is so rigorous as on the borders of Lake Superior, and where for months in succession the thermometer does not range above the freezing point, there is too much uncertainty connected with the use of the latter. In the stamping-mills, during the intensely cold weather, it becomes necessary to resort to fires to prevent the steam from congealing on the engine, in long icicles, and the ice from forming on the stamp-heads. In an extensively opened mine, giving employment to many hundred people, uncertainties of this kind must be avoided. The work must progress from day to day, the stopers following fast on the drivers.

The usual whim employed in the mines is exhibited in the annexed cut:

Fig. 19.



A vertical axis supports a drum on which a rope is wound and unwound the rope passing over fixed pulleys, called poppet-heads, and being attached to the two kibbles or buckets, one of which descends as the other ascends. In raising the heavy masses of copper at the Cliff mine, a powerful capstan is used, in connexion with suitable tackle, by which a weight of several tons can be raised.

Having thus briefly noticed the general nature of the exploration, we will now proceed to describe the principal mines in this district; and to illustrate the method of working, and the progress of the under-ground operations, we have prepared several sections, taken principally from surveys and measurements of Mr. Hill.

CLIFF MINE.

The Cliff mine is situated on Keweenaw Point, about three miles from the lake shore, in the southwest quarter section 36, township 58 north, range 32 west. A range of elevated hills sweeps round in a crescent form, trending in a southwesterly direction, and forming the western boundary of the valley of Eagle river. In places these hills attain an elevation of 800 feet, and towards the valley present bold mural escapements, while on the side exposed to the lake the slope is gradual. This range is composed of trappean rocks. The summit is capped by a hard crystalline greenstone, as at the Cliff mine, passing into a feldspathic porphyry, as at the Albion. Below, and forming the base of the ridge, is a belt of granular trap, occasionally amygdaloidal. Between the two there is a thin belt of slaty chlorite about twelve feet in thickness. These belts dip to the north at an angle of 45°, conforming in this respect to the inclination of the detrital rocks which flank the range on the north. Wherever veins are observed in the greenstone, they are found to be pinched and barren; but where they enter the compact or granular trap they expand in width and become charged with metal. This trap has a good degree of firmness, and consists of labrador feldspar, and chlorite. It has been remarked that the best rock in this region for productive veins is neither a crystalline greenstone nor a soft porous amygdaloid, but a granular trap, with occasional amygdules scattered through it, and possessing a good degree of consistency. Where veins enter the greenstone, as before remarked, they become pinched; where they penetrate the soft amygdaloid, they become scattered and lose themselves.

The lode of the Cliff mine is seen to occupy a break or depression in the hill, and thence can be traced to its base. It was discovered in the summer of 1845, and during the succeeding fall a drift was carried into the greenstone about one hundred feet, (see plan, A,) and between that point and the summit several others were opened. When first discovered, the vein could only be seen in the upper belt of greenstone, the metalliferous zone being concealed by detritus. No one could have inferred from its appearance at that time that the enormous masses of copper existed but a short distance below which subsequent explorations revealed. It was examined by Dr. Jackson and Mr. Whitney conjointly, about the time of its discovery, who reported that the surface indications were not highly favorable at the points where the vein was exposed, but that, as it became wider and richer in its downward course, the company should by all means make a thorough examination by uncovering and examining the vein at the base of the cliff. At the summit it appeared hardly more than an inch or two in width: the gangue was mostly prehnite, with copper associated with silver, incrusted with beautiful capillary crystals of red oxide. Further down the vein was again exposed; here it had expanded to the width of nearly two feet, the veinstone consisting of a series of reticulations of laumonite.

Up to this period the sandstone and conglomerate were supposed by many to afford the best mining-ground, and that to this source they were to look for permanent supplies of the sulphurets of copper.

During the winter of 1845–'46, some German miners, in clearing away the talus near the base of the cliff, discovered a small loose specimen of mass copper. This stimulated them in their researches, which resulted in the discovery of the vein in the belt of granular trap (*b*) about twelve feet to the east, showing that it had been subjected to that amount of heave or dislocation. From that point a level was carried into the hill seventy feet before anything valuable was developed, when the great mass, so called, was struck—a fortunate circumstance, not only to the company, but to the whole mining interest on Lake Superior. It gave encouragement to those engaged in these pursuits, and induced them to persevere. It also demonstrated the true source from which the loose masses occasionally found on the lake shore had been derived. It demolished the fanciful theory advanced by at least one geologist as to the transport of the Ontonagon mass from Isle Royale, and showed that it was not necessary to resort to icebergs and changes in the relative level of land and water to account satisfactorily for its position. From that time to the present day, hardly a month has elapsed without developing new masses; and their occurrence, so far from creating wonder, is regarded as a matter of course. The largest single mass hitherto exposed weighed about fifty tons. The position of the mass copper in the vein is indicated by the spaces between the dotted lines marked M, while the intervening spaces, marked S, afford stamp work.

It will be seen, by reference to the plan, that the levels 1, 2, and 3 have been extended northwardly into the greenstone before described, but in no instance has the vein been found after having pierced that rock. This arises probably from the lateral dislocation before referred to, the true position of the vein being twelve feet to the west. As a matter of curiosity even, it would be desirable to cross-cut to determine the extent of this fault, and the character of the vein where it enters the greenstone. It will,

without doubt, be found less metalliferous at that point than in the granular trap which contains the present workings.

The deepest shaft in this mine has been sunk 270 feet below the surface. The other two are little less in depth. The adit, which drains the mine to the depth of 100 feet below the first gallery, has been extended 750 feet. The amount of stopeing and timbering, and the disposition of the *attle*, or rubbish, will be seen by inspecting the plan.

The force employed in this mine at the present time consists of 160 men. The mine is under the management of Capt. Jennings, who has displayed much energy and judgment in developing it. If any criticism may be allowed, it would be to the effect that there has been no increase in the force for the last eighteen months. The openings in the mine should be in advance of the stope work. By pushing these forward the country is explored, ample space is given to the miners to work, and opportunities from time to time afforded to increase the force.

The machinery employed for raising the ore and freeing the mine from water is admirably contrived; but the mine is now so thoroughly opened that the company will soon substitute a steam-engine in the place of horse-power. The stamps erected here were the first which operated successfully, and have served as a model for the mines in other parts of the district.

The connexion between the different parts of the mine is exhibited in Plate VIII, which is to be regarded as a plan, rather than a landscape. The cliff in the back ground consists of the crystalline greenstone before described. The vein traverses it in a nearly perpendicular direction, pierced by several galleries which extend no great distance, as will be seen by reference to the section, Plate VII—the vein here proving to be contracted and meagre in metal. The mining ground, represented in Plate VII occurs below the cliff of greenstone in a belt of amygdaloidal trap, and the relations of the two rocks are exhibited in the plan last referred to. The poppet-heads and whims for raising the ore and water are seen at the entrance of the shafts. The building near the centre is used for calcining the rock preparatory to stamping it, assorting the ore, and cutting the mass copper. The building on the extreme right contains the stamps and washing apparatus, which will be described in detail in another chapter. The productiveness of this vein may be inferred from the amount of stopeing which has been done, which is represented by the dark portions in the section, Plate VII. The disposition of the attle is also there represented.

From the reports of the trustees rendered in 1849 and 1850 we gather the following information:

The amount of capital stock paid in by the stockholders = $110,000. The personal effects of the company on the 1st of December, 1848, were $140,982, leaving a surplus of $111,105—a sum a little more than equivalent to the entire capital stock. This statement does not include the mine, with its fixtures and improvements, such as the stamping-mill, furnace, &c.

The net products of the mine, and the expenses of mining proper, from the commencement, are given below:

	Products.	Expenses.
1846 - - - - -	\$8,870 95	\$32,203 44
1847 - - - - -	70,977 32	61,737 85
1848 - - - - -	166,407 02	67,667 58
1849 - - - - -	244,237 54	106,968 77

This embraces such expenses only as were incurred at the mine; those of insurance, commissions, freights, &c., are excluded. The cost of transportation to Boston is \$15 per ton; to Pittsburg, \$7 50. The incidental expenses amount to about 20 per cent., in addition to those of mining.

The company have erected the necessary works at Pittsburg for smelting and refining the copper, and they estimate that the shipments for the year ending December, 1849, will amount to 660 tons of refined copper.

The product of silver for the year 1849 was \$2,365 30.

The following table exhibits the monthly products of the mine for the two years ending December 1, and the character of the ore. It will be seen that, while the amount of the barrel and stamp-work has increased, the amount of mass copper has slightly diminished.

Statement of the monthly yield of copper during the years 1848 *and* 1849.

CLIFF MINE.	BARREL-WORK. 50 per cent.		MASSES. 65 per cent.		STAMP-WORK. 5 per cent.		Total, in pounds.	
Months.	1848.	1849.	1848.	1849.	1848.	1849.	1848.	1849.
December	31,843	50,007	161,221	55,354	140,000	571,500	333,064	676,861
January	34,770	40,756	147,687	73,159	150,000	514,500	332,457	628,415
February	36,187	20,685	117,417	79,405	186,500	529,500	340,104	629,590
March	50,585	22,864	146,936	48,669	358,500	553,500	556,021	625,033
April	58,222	21,298	97,631	43,692	328,000	338,500	483,853	453,490
May	33,981	90,129	102,155	99,600	311,000	424,500	447,136	614,229
June	52,797	88,562	97,364	92,874	393,392	325,500	543,553	506,936
July	41,280	57,932	59,633	93,385	309,000	399,000	409,913	550,317
August	42,374	55,082	65,062	236,237	490,500	504,000	597,936	795,319
September	35,574	50,303	47,490	88,401	508,500	396,000	591,564	534,704
October	30,667	41,371	73,734	103,081	390,000	480,000	494,401	624,452
November	38,207	27,325	93,552	64,027	314,000	468,000	445,729	559,352
Total	486,487	566,314	1,209,852	1,077,884	3,879,392	5,584,500	5,575,731	7,228,698

North American mine.—This mine is situated in the NW. quarter of section 2, township 57 N., range 32 W. Its geological position is similar to that of the Cliff mine before described, both being in the same range of cliffs, and occupying adjoining quarter sections. The veins, however, are distinct. From the surface to the point B, in the smaller shaft, the lode dips 23° below the horizon, where it is intersected by a small vein or feeder, beyond which, in its downward course, it dips but one foot in six. The following sketch represents a cross-section above the point B. Here, the lode was found to be of little value, contracting to a foot or eighteen inches in width, and affording stamp work of an inferior quality. Below, it increases in width, and becomes highly metalliferous. At the point C, another feeder comes in, which, like the former, enriches and expands the lode still further. The walls are very variable. In some places, they contract to a mere fissure; again they expand to seven feet. This expansion is observed where the vein C comes into the main lode. Through the entire length of the lower level, it has been found good, containing in some places mass copper. From an examination at the depth of ninety-five feet, it is inferred that the veinstone is 3 or 3½ per cent. richer than that taken from the second level. The stamp-work, at present, yields about 7 per cent. This estimate, we are aware, is 3 per cent. lower than the agent rates it. From every bunch of ore containing 30 tons there are taken 4 tons of what is called barrel work, yielding 40 per cent. of copper, and the addition of the masses at 60 per cent. will make the average yield of the contents entire not far from 9½ per cent.

Fig. 20.

The gross amount of copper taken from the mine during the past year is not far from 1,400 tons, which will yield 129½ tons of pure copper.

The mine has not been opened sufficiently, except within the last seven months, to admit workmen to advantage. Thirty-five tons of copper have been sent to market during the past season, and the product for the next season may be safely rated at 200 tons. When fairly opened, it will annually yield from 400 to 600 tons of pure copper.

The stamps connected with this mine are the best hitherto erected in this region. They are driven by a steam-engine, and with eight stampers are capable of turning out 80 or 90 tons per week.

Appended to the section is a view of the vein as it appeared at the point A, in the lower level, 180 feet below the surface. A sheet of native copper, one foot in diameter, was seen to occupy the foot-wall, and to extend from the bottom to the top of the gallery. The other portion of the vein, one foot in thickness, was composed of calc-spar, quartz, chlorite, and epidote, filled with small spangles of copper. Its course is N. 58° W.—cutting across the formation.

This mine at the present time gives employment to 61 miners and 24 surface-men. The monthly pay of the former amounts in each case to $24; of the latter, $20.

These workings have been prosecuted under many disadvantages and discouragements; but through the energy of Mr. John Bacon, the agent, they have been overcome, and the company are in the possession of one of the most valuable mines in this region.

Minnesota mine.—This mine is situated about two miles east of the Ontonagon river, and fifteen miles from its mouth, (NW. quarter section 15, township 50 N., range 39 W.) The trap ranges here run in a NE. and SW. direction, and attain an elevation of about 700 feet above the lake. Like the range of Keweenaw Point, they are flanked by sandstone and conglomerate, dipping northerly, besides containing intercalated beds of these detrital rocks. The section of the adit appended to the plan of this mine shows the relation of one of these sedimentary beds to the igneous formation.

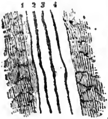
This vein belongs to a system totally distinct from that of Keweenaw Point. While the latter system crosses the formation at nearly right angles, the former has a course and inclination nearly conformable to those of the accompanying sedimentary rocks.

The inclination of this vein is north 52°, which is parallel with the sandstone seen at tho base of the hill. (*Vide* section of the adit before referred to.) The veinstone consists of epidote, chlorite, quartz, and calc-spar, distinct in character from the wall-rock. The walls of the vein are, for the most part, well defined, exhibiting the grooved and polished appearance, termed by the Germans *slickensides*. Throughout the gangue, copper exists in masses, bunches, and spangles. Silver occurs in places in connexion with calc-spar and chlorite, one specimen of which weighed eight ounces. In the spring of 1849, we examined this mine before any stopeing had been done. The drift had been extended betwoen the two shafts, 156 feet apart. At the point of intersection between shaft No. 1 and the drift, a mass of nearly pure copper five feet in thickness was exposed, occupying the hanging-wall. A few feet east, it was observed to change its position and occupy the foot-wall. The sheet copper appeared to be nearly continuous between the two shafts. The width of the vein at the point where the level intersects the shaft No. 1 was found to be eight feet, but at shaft No. 2 contracted to three feet. This increased width is due to a feeder or branch which intersects the main lode and becomes merged with it, where shaft No. 1 is sunk. To the west of this point, a drift has since been extended eighteen feet in length and thirty-eight feet below the surface. Here, the vein expands to eight feet, and is almost entirely filled in with sheets of native copper. Shoots branch off from the main mass, occupying the fissures, so as to interpose a brazen barrier to further driving in that direction. These masses can only be reached by stopeing from the adit-level upward until they are intersected, and then driving along their sides. By means of powerful sand-blasts placed between the sheets and the hanging-wall, they can be thrown down; after which, a great amount of labor remains to be performed, in cutting them into blocks, so that they may be removed to the surface, where they must undergo still another subdivision into blocks of one or two tons weight, that they may be transported to the river. The sheets between shafts Nos. 1 and 2, where the vein was stoped, yielded no masses of any great thickness. At shaft No. 2, 42 feet below the surface, a mass of copper was struck, and the sinking continued beside it to the depth of 55 feet, which was found extending into the level westerly. Portions of this mass were taken down, while other portions remain on the hanging-wall. These points are indicated by the letters M, M. Here, the vein is five feet in width, composed not entirely of materials distinct from the wall-rock, but of intercalated portions

of trap. This was the character of the vein between shafts Nos. 1 and 2. In shaft No. 3, 180 feet west, the vein is 28 inches in thickness, including the rocky portion, and presents the following section:

Fig. 21.

1 2 3 4



1. Quartz and chlorite, with copper in strings and bunches.

2, 3. Beds of rock, similar to the wall-rock, with thin sheets of copper filling the seams, in sufficient abundance to pay for working this portion of the vein.

4. Quartz, chlorite, calc-spar, and epidote, containing a large per centage of copper, in masses, bunches, and disseminated.

In certain portions of the lode, these beds of rock disappear, the whole matrix being filled with materials distinct from the walls.

According to the statement of Mr. Knapp, the agent of this mine, whose energy and zeal in exploring this tract we have noticed under another head, there were taken from this mine, last year, (1848,) eleven tons of copper, seven and a half of which were included in the mass raised by the ancient miners, the position of which is indicated in the plan. (See shaft No. 1.)

This was sent to market before the company had fairly commenced operations. During the past season, there have been taken from the mine 57 tons of copper, in masses, estimated at 75 per cent., and 700 tons of stamp-work, estimated at 6 per cent., making in the aggregate 84¾ tons of pure copper—the mass of the veinstone yielding nearly 11¾ per cent. There are now exposed, in the shafts and levels, about 30 tons in masses, besides a considerable quantity of stamp-work.

A year has not elapsed since this mine was opened, and none of the shafts have been extended to a greater depth than 57 feet. No mine in the country has produced so great an amount of copper, with the same amount of labor and capital expended. We cannot find its parallel in the whole history of copper-mining, wherever prosecuted.

Plan of the mine.—An adit-level is now being driven from the base of the hill to intersect the vein, at nearly right angles with its course, at shaft No. 3. Its length, when completed, will be 375 feet. Thence, it will be extended along the course of the vein so as to strike the several shafts. Shaft No. 1 will be intersected 77 feet below the surface; shaft No. 2, at 87 feet; and shaft No. 3, at 86 feet. The shaded portions represent the present workings, while the light portions show what remains to be accomplished. The ancient workings are indicated by a series of oblique lines.

The Minnesota vein can be traced along the surface for the distance of a mile or more, and in this respect it admits of the employment of a greater number of miners than any vein yet discovered in the copper region. The containing rock is a dark-gray, mottled trap, of a granular texture, with occasional almond-shaped cavities through it. It breaks into rhomboidal blocks, and readily yields under the drill. Its constituents are hornblende, feldspar, and chlorite.

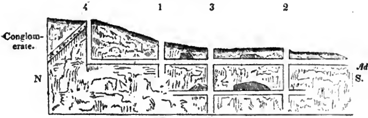
The section of the adit protracted 300 yards north cuts no less than six veins, some of which conform in dip to the vein now wrought, while others intersect the rocky planes perpendicularly.

The company now employ 84 men, about one-half of whom are assigned to the mine, while the other half are employed in erecting the

necessary buildings. These will consist of a whim-house, a house for calcining and assorting the ore, a stamping and washing-mill, with a saw-mill attached. They have already erected five dwelling houses, two smitheries, two barns and other out-buildings, and a commodious warehouse, on the right bank of the Ontonagon. They have constructed an excellent road to the river, 2½ miles distant, and cleared and cultivated about 45 acres of land. They raised during the past year 500 bushels of potatoes, 300 bushels of turnips, and other vegetables. This work seems almost incredible, when it is considered that, a year ago, there was hardly a tree felled on the location, hardly a cubic foot of rock excavated from the vein.

Northwest mine.—This mine is situated on Keweenaw Point, (section 15, township 58 N., range 30 W.,) in the same belt of trap in which are contained the Cliff and North American mines. It occurs on the southern slope of the northern trap range, and overlooks the valley of the Little Montreal river.

Fig. 22.



The above sketch will convey an idea of the nature and extent of the workings. The rock is a dark gray compact trap, occasionally amygdaloidal. To the north of shaft No. 4, occurs a belt of conglomerate about 12 feet in thickness, with a northerly inclination of 40°, reposing on a brecciated trap. Within a space of 300 yards are three distinct and well-defined veins, whose bearing and underlie are as follows:

East vein,	bearing north	16½°	east, underlie	8° east.
Middle vein,	" "	19°	west, "	8° west.
West vein,	" "	17°	west, "	12° west.

It is not improbable that all may ultimately be found to converge and form a single lode of great power. The main workings have been prosecuted on the eastern vein. An adit-level has been driven 500 feet; when extended 136 feet farther, it will intersect shaft No. 4, at the depth of 73 feet. Another gallery has been opened, 60 feet below, and a portion of the lode removed, the stopeing being represented by the shaded lines. The vein, along the course of the adit, is well defined, and varies in width from a few inches to two feet. In the northern part, where the present workings are prosecuted, it expands to 2½ feet, and is highly charged with copper.

At the northern extremity of the second level, the vein is 31 inches in width. At the bottom of shaft No. 3, 90 feet from the surface, the vein is observed to have a greater expansion than at any intermediate point.

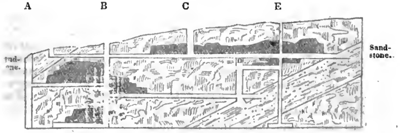
Its impregnation appears to have taken place at two different periods. The western seam is composed of chlorite and calc spar, with but little quartz; the copper occuring disseminated and in thin plates. The eastern seam is composed of quartz and calc-spar, with but little chlorite—the copper occurring in masses, bunches, and strings.

Where the fissure was observed to be subsident, the walls came almost in contact. Where, on the other hand, the fissure was nearly perpendicular, the vein had the widest expansion.

Two shafts have been sunk on the west vein, each to the depth of 50 feet. From one of these a level has been extended 80 feet, and a portion of the lode removed, and masses weighing a ton and upwards have been taken down. This vein promises to be of great value. The product of this mine, according to the best information, up to the present time, has been 50 tons of mass copper, yielding 50 per cent., and 500 tons of 8 per cent. stamp work. The present force employed consists of 53 miners and 42 surface men.

Copper Falls' mine.—The old mine is situated on the northern slope of the trap range, about two miles from the lake shore. Within that space there are four alternations of trap and conglomerate. The belt in which the lode is situated is only a hundred and fifty feet in thickness, and dips northerly at an angle of 33°. A belt of conglomerate reposes upon it, forming the northern slope of the hill; while a belt of metamorphosed sandstone, fifty feet or more in thickness, occurs below. The annexed sketch illustrates the relative position of the igneous and aqueous rocks.

Fig. 23.



So long as the workings were confined to the belt of trap, the vein was productive—yielding stamp-work and masses, the largest of which weighed 12 tons. On striking the sandstone, however, it was observed to change in its mineral contents and richness. The shaft E, has been extended through the sandstone into the belt of trap below, and the fissure appeared to be continuous through the different formations; but at the depth of 6 feet in the sandstone, the vein had contracted to four inches. Shortly after the intersection it was observed to branch—one branch dipping rapidly to the west, and the other to the east. The shaft was continued perpendicularly through the sandstone, thus losing sight of both branches. On reaching the lower belt of trap, a drift was extended to the right and left, to the distance of 18 feet, without intersecting either branch. In this stage the workings were suspended. It is desirable to have these workings continued still further, as they will solve one of

the most interesting problems in the mineral region—*i. e.*, the changes which veins undergo in their passage through different mineral planes.

The company are now developing a vein between sections 11 and 12, known as the Childs vein. Its geological position is the same in reference to the sandstone as the one before described. It bears east of south, and dips westerly. A few feet to the west, another vein can be traced along the surface, in which may be seen pits which were sunk by the ancient miners. An adit has been commenced, which will be extended 256 feet, when it will intersect the shaft on the Childs vein at the depth of 64 feet, and in its progress develop the other vein.

The belt of trap is much wider at this point than at the abandoned mine. In sinking the shaft, some masses of copper were found weighing from thirty to fifty pounds; but the disseminated copper was inconsiderable.

Near the centre of section 12 is another vein, on which a shaft has been sunk to the depth of thirty-seven feet, without having developed much copper. The vein is about a foot in width, the gangue of which consists of calcareous spar, with traces of chlorite. The shaft is in the upper portion of the trap belt which underlies the sandstone at the old works, and takes into its composition a large proportion of chlorite.

Thirty rods to the south-southwest is another vein of much greater promise. The course is nearly north and south, and the matrix consists of prehnite, highly charged with particles of copper.

The total product of this mine up to the present time is as follows:

Copper masses and barrel-work, averaging 70 per cent.	90,959 lbs.
Stamp-work, averaging 10 per cent.	497,500 "
Total	588,459 "

The Northwestern mine is situated in the same trap belt as the Northwest—the same stratum of conglomerate showing itself near the brow of the hill. It is in section 24, township 58 north, range 58 west. The vein crosses the formation, bearing northerly. Two trial shafts have been sunk to the depth of twenty-four and thirty-six feet respectively, which yielded copper, in masses and disseminated, in considerable abundance. The indications are that this is a vein of much power, and the company in possession ought to test it thoroughly.

Phœnix, formerly Lake Superior, mine occurs in the bed of Eagle river, about a mile above its embouchure. This tract was among the first located in this region, and this company among the first to embark in mining adventures. In the early days of copper-mining, this lode was represented as possessing unparalleled richness—the silver far exceeding the copper in value; and these representations contributed powerfully towards the creation and maintenance of the copper mania which prevailed for a time throughout the eastern cities. The most extravagant expectations were formed, and the most exaggerated statements* made, as to the mineral wealth of the country. Many were doomed to a speedy and bitter disappointment; but the ultimate effects have been to divert capital into a new and untried channel, and develop the mineral wealth of a

* The first report of the trustees contains a statement of the result of an assay as follows: In a ton of rock—

Silver, 152.56 pounds, valued at	$3,053 20	
Copper, 203.57 pounds, valued at	83 57	
		$3,136 77

region which, but for these representations, might have remained for a long time unexplored.

This vein, as before remarked, is situated about a mile from the lake shore; and between these two points there are no less than seventeen alternations of trap and conglomerate. From the fact that veins exhibit great disturbance and great variableness in their metallic contents in their passage through different belts of rock, it is evident that the best mining-ground lies south of these alternations. In that direction, however, it is circumscribed by a belt of hard, crystalline greenstone, in which the veins are seldom well developed.

The lode is seen in the bed of the stream about a thousand feet above the main shaft, where it is distinctly marked. The matrix consists of calc-spar, prehnite, and radiated quartz, containing native copper in strings and disseminated. It is from one to two feet in width, and bears north 17° east, with a slight dip to the east. Thence it is to be traced down the stream, occasionally concealed by loose rocks and gravel. In the winter of 1844, a trial shaft was commenced at this point, on the left bank of the stream. This, however, had been prosecuted only to the depth of twenty feet, when it was, under the direction of the mining engineer, abandoned, and another shaft commenced further down the stream. Here there was no appearance of a vein; no gangue distinct from the wall-rock; no powerful fissure to indicate the dislocation of the mass; no polished surfaces on the face of the cliff. The true position of the vein was several feet to the east, in the bed of the stream; but it was not apparent, from the accumulation of water-worn materials. The shaft was sunk through a dark-brown amygdaloid, with little adhesion between the particles—the amygdules being filled in places with native copper, exhibiting occasional points of silver. This peculiarity could be traced for a distance of eleven feet from the stream, becoming less apparent as it receded from the bank. On the immediate bank, however, the rock was less amygdaloidal, and took in a larger proportion of chlorite. The change in the location of the shaft was injudicious in two respects: 1. The old shaft was on the vein, and, had it been prosecuted, would have proved it, while the new shaft was not on the vein, but to the west of it. 2. It was located so near the river bank, that the water percolating through the fissures proved a constant source of annoyance, in the progress of the work.

In his report to the company, the mining engineer represents the vein as eleven feet in width—a vein of greater power than any three thus far discovered in this region—eighteen hundred feet in length, as far as known, and containing an amount of ore, already exposed, which could not be exhausted within the present generation.* Its richness was unparalleled. As the shaft was continued downward, the indications of copper became less apparent, until finally they disappeared altogether, and nothing was brought up but barren rock.

At the depth of 60 feet, if we mistake not, the miners came to a pocket in the rock filled with gravel and water-worn accumulations. They then drifted

* We quote from the report: "The whole known length of the vein is about eighteen hundred feet. *Its width is satisfactorily proved to be eleven feet for the distance of two hundred feet;* and it is probable that it will hold a workable width throughout the eighteen hundred feet. It is obvious that there is an adequate quantity of rich ore in this vein to render the work very profitable, and that there is no danger of exhausting the ore, even should it give out at the depth of one hundred feet, of which there is no probability. * * * If the ore runs out at a considerable depth, say, two hundred feet, it will be a matter of little importance to *the present generation, though it might be to posterity.*"

under the bed of the stream in pursuit of the vein, but were unsuccessful. In removing the water-worn materials, they found numerous boulders of copper, varying in weight from half an ounce to 600 pounds—so numerous, indeed, that portions of the gravel were profitably washed for the metallic contents. In this connexion was also found a mass of native silver weighing eight pounds—the largest yet discovered in this region. The main shaft was carried to the depth of 75 feet, when the workings were suspended; nor have they since been resumed.

That there is a vein of great richness on that location, and in the vicinity of the present workings, is evidenced by the numerous water worn masses of copper found in the bed of the stream. They have not come from far. As the matrix of the vein is more yielding than the associated rocks, it frequently prescribes the direction of a stream and forms its bed. That will probably be found the case here. The pocket before described was excavated by the agency of the stream in the gangue of the vein.

The west vein on this location, known as Sheffield & Nott's, is about 11 inches in width, and bears north 19° west. The veinstone consists of chlorite and calc-spar, traversing greenstone, resting on a porous amygdaloid. A trial shaft has been sunk, which afforded indications of considerable value.

Lac la Belle mine—Bohemian mine.—The workings of these companies have been prosecuted on the same vein—those of the former in the base of the Bohemian mountain, those of the latter on its summit.

This mountain rises to the height of 864 feet above Lac la Belle, and from its summit is afforded a view of great extent and beauty. The rock consists of chlorite and feldspar of a highly crystalline texture, and appears to be of an age posterior to the bedded trap in which the mines before described are situated, since these beds are found dipping from it like the strata of detrital rocks. It was protruded in vast irregular masses, forming a continuous line of elevation. The metallic contents of this rock are entirely distinct from those of the bedded trap. While the latter is characterized by veins of *native* copper, the former abounds in the *sulphurets* of copper, such as the gray and black sulphuret and copper-pyrites.

Two sets of veins have been observed—one bearing north 26½° west, which appear to be the main ones, and another bearing north 80° east. The gangue consists of calc-spar, chlorite, and quartz. Two shafts have been sunk near the summit of the hill—one to the depth of 106 feet, the other to the depth of 75 feet—without developing a rich vein.

The Lac la Belle Company extended a drift into the hill, 309 feet above the lake-level, to the distance of nearly 400 feet. They found the vein 18 inches in width, and rich in the sulphurets. Their main efforts, however, have been concentrated on an adit which starts 25 feet above the level of the lake, and has been driven 900 feet. As they have probably left the main vein in the prosecution of the work, its value cannot be determined at this depth without a cross-cut.

No place on Lake Superior affords greater facilities for mining; and the efforts of the company deserve to be crowned with success.

Quincy mine is situated near Portage lake, on section 26, township 55, range 34. The surface of the country rises somewhat abruptly from the water, not in broken cliffs, but rounded hills. The elevation of this

mine is, by estimation, 400 feet. The rock is a dark-brown trap, composed of hornblende, feldspar, and chlorite. The vein bears north 43° east, and dips rapidly to the north, corresponding with the course of the formation—the only instance of the kind observed on Keweenaw Point. A string or branch was observed in a ravine near by, bearing north 45° west, which yielded native copper in sheets of considerable size. This mine, at the time of our visit, had not been sufficiently developed to enable us to form an opinion as to its value.

Forsyth mine occurs in the southeast quarter of section 33, township 57, range 32. The vein, which bears north 9½° west, is distinctly seen cutting a hill, which rises a hundred feet above the surrounding plain. Two years ago, a shaft was sunk to the depth of 70 feet, and two others to an inconsiderable depth, since which time the work has been abandoned. As the water had filled these excavations, it was impossible for us to examine the vein critically. From the veinstone brought to-day, copper in sheets and disseminated was found in considerable abundance. Native silver was also found in this association to an extent thus far unobserved in any other mine on Lake Superior. The external indications here are favorable; but we are not advised whether the company purpose resuming operations.

Albion mine is situated in the same bluffs as the Cliff and North American, on section 11, township 57, range 32. The cliff, which attains an elevation of nearly 800 feet above the lake, is composed of a hard crystalline greenstone, passing into a porphyry, where the crystals of feldspar are imbedded in a matrix of hornblende. On the western slope, a thin but well-marked vein, filled with arsenical, pyritous copper, is observed occupying a depression in the soil for a distance of 80 rods. Mr. Stevens, the agent of the company, informs us that at either end it branches into numerous strings and becomes lost.

On the southeast side of the bluff, a shaft has been sunk to the depth of one hundred feet, striking the amygdaloid at the depth of 97 feet, from the bottom of which a drift was extended into the hill along the course of the vein. The workings have not been prosecuted sufficiently to determine its value. This vein bears north 46° west. Its matrix consists of calc-spar and chlorite, with thin scales of native copper, and is about 18 inches in width.

Forest mine.—This mine is situated on the northeast quarter of section 36, township 50, range 40, within the limits of what is known as the "Cushman location," on the left bank of the Ontonagon river. The old workings, under the direction of Cushman, on the north half of section 36, do not appear to have developed veins of much value. They have been described in a preceding part of this report.

"The Dutch vein," on the northeast quarter of section 31, has been explored to the depth of about fifty feet. Its course is north 70° east, ranging with the formation; its inclination, 40° below the horizon. The veinstone is composed of epidote and quartz, twelve feet in thickness, with thin plates of copper disseminated through the mass, affording indications of considerable promise.

In the chapter on ancient mining we have described with some minuteness the pits and excavations found on the southwest quarter of section

30, and on section 31. The following sketch may be regarded as an approximative representation of the contour of the cliff, and of the position of the veins on the latter tract. The inclination of the main lode is 78°.

Fig. 24.

The ancient miners had excavated to the depth of 19 feet, and this has been continued by the adventurers to the depth of 23 feet. The two veins to the south, from their inclination, probably intersect the main one at points below the 23-foot excavation. Should the inclination be found to continue cutting the strata or bands in the same plane, it will present the same phenomena as the main veins in Cornwall. A section of the vein, as it appears in the shaft, is appended. The wall-rocks are composed of amygdaloid and granular trap, with a large admixture of chlorite. The vein, which is about three feet in width, is composed of the following materials, and arranged in this order:

Fig. 25.

1. A seam of laumonite an inch in width.
2. Calc-spar, quartz, chlorite, and epidote, with copper in bunches and disseminated.
3. Carbonate of copper, probably the result of atmospheric changes.
4. Epidote, chlorite, and amygdaloidal trap.
5. Masses of copper associated with spar, quartz, and epidote.

To the east of this shaft another has been commenced, at the bottom of one of the ancient excavations. At this point the vein exhibits very much the same appearance, having the same inclination, and yielding copper in considerable abundance. Few veins in the mineral region have been opened which, on the surface, afforded indications of greater promise.

Ohio Trap Rock mine.—The workings at this point have been described with some minuteness in a preceding part of this report, and it would be superfluous to repeat the information there given.

Adventure mine—southwest quarter of section 36, and southeast quarter of section 35, township 51, range 38, in the Algonquin mountains. A cliff rises to the height of more than 150 feet above the surrounding country, and to the south presents a bold mural escarpment, while to the north it slopes gradually towards the lake. The rock is a hard, crystalline greenstone, somewhat porphyritic, traversed by occasional strings or seams, filled in with calc-spar and epidote, associated with native copper. We saw no well-developed vein—nothing to indicate a permanent supply of metal. A shaft has been sunk on one of these strings to the depth of 20 feet, near the brow of the cliff.

The Ridge mine is situated on the southwest quarter of section 35, township 51, range 38, and is in the same axis of upheaval. Workings have been prosecuted only to a limited extent. The ground in the vicinity exhibits numerous pits—the work of a former generation. At one point a vein is exposed, included within a feldspar and hornblende rock, dipping to the north, which affords copper in strings and disseminated. This vein, like most of the veins in the region between Portage lake and the Ontonagon river, has a bearing and dip corresponding with the adjacent stratified rocks.

The Aztec Mining Company occupy the northeast quarter of section 36, township 51, range 38, and the northwest quarter of section 31, and

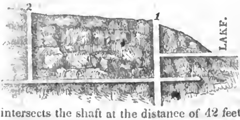
the southwest quarter of section 30, township 51, range 37. The point where mining operations have been commenced is on the northeast quarter of section 31. A vein is seen near the brow of a cliff, bearing west-southwest, and dipping to the north at an angle of 46°. It has not been sufficiently opened to enable one to form an opinion of its value.

The Douglass Houghton mine is on the northeast quarter of section 15, township 51, range 37. Two years ago the vein was opened to the depth of 40 feet, when further operations were abandoned, but the work has been resumed, under the direction of Mr. C. C. Douglass, one of the most efficient mining engineers in the region. The vein, which traverses a compact chlorite trap, is about three feet in width, running nearly north and south, conforming to the general direction of the ridge at this place, and dipping west 60°. They have driven a level about 25 feet along its course, and a considerable quantity of copper has been obtained. The veinstone removed was rich in disseminated and string copper, and will yield from 8 to 12 per cent. of metal. Quartz, much of which is colored red with the sub-oxide of copper, forms the principal portion of the matrix, which is traversed by numerous seams of chlorite. The vein is well defined, and affords indications of proving highly valuable.

The *Algonquin mine* is on section 36, township 52, range 37. It has been temporarily abandoned for the last two years, and no work worthy of description has been done here. All of the information in our possession will be found under the head of "Geology of the trap region."

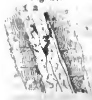
The Pittsburg and Isle Royale Company are developing a vein on the northwest quarter of section 12, township 65, range 36, near Todd's Harbor, Isle Royale. The following diagram will represent the present condition of the work:

Fig. 26



The vein traverses a hard, crystalline greenstone, bearing N. 20° E., with an underlie of 12° to the east. Shaft No. 1, has been sunk upon it to the depth of 63 feet. Shaft No. 2, reaches to the depth of 67 feet. Adit No. 1, starts from the water's edge, and intersects the shaft at the distance of 42 feet. The second level connecting the two shafts is 113 feet in length. Near the surface the vein appears pinched—attaining a width of only a few inches; but at the extremity of the 113 foot adit, and 50 feet below the surface, it expands to a width of 18 inches, and presents the following section:

Fig. 27.



1. Sheet of native copper, varying from one-half to one and a half inches in width, and nearly continuous, occupying the foot-wall.

2. Veinstone of calc-spar, quartz, prehnite, and laumonite, with diffused copper.

At the entrance of the drift the sheet copper is observed to occupy the hanging-wall, but it very soon crosses the vein and continues in contact with the foot-wall so far as it is explored.

This is the best-developed vein we have observed in the hard rock. At the entrance of Todd's Harbor a belt of amygdaloid of a reddish-brown

color is observed dipping under the greenstone at an angle of 45°; and if the shafts are protracted to a sufficient depth, they will intersect it, when the vein will probably be found to undergo some modification.

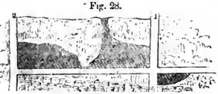
The company have sent to market 4,483 pounds of copper, which yielded 75 per cent. of pure copper. The mass of the veinstone, however, will not yield 10 per cent.

The largest mass of native copper taken from this lode weighed about 700 pounds.

The company now employ in and about the mine 26 men, who are pressing on the work vigorously, and with very fair prospects of success.

Siskawit mine adjoins Rock Harbor, Isle Royale, and occurs on the southwest quarter of section 13, township 66, range 34. The vein bears nearly east and west, with an inclination of 75° to the north. For forty feet in its downward course it cuts a belt of dark, granular trap, composed of hornblende, chlorite, and feldspar, after which it intersects a belt of columnar trap. While confined to the granular trap, the vein was well developed, and yielded considerable copper in masses and stamp-work; but having entered the columnar trap, it contracted to a mere fissure, the veinstone and metallic contents disappearing. The subjoined sketch represents the workings. Two shafts have been sunk through the chlorite trap, intersecting the columnar trap in one instance at the depth of 35 feet, and in the other at 40 feet. West from shaft No. 2, 1,800 feet, another shaft has been commenced.

Fig. 28.



The veinstone consists of calc-spar, chlorite, and epidote, with copper disseminated in small scales and points; also in masses, the largest of which observed by us weighed 350 pounds.

This company have other tracts on the northern side of Isle Royale which contain veins, but, as they have been only partially explored, we will not pause to describe them.

Ohio and Isle Royale Company.—The operations of the company are at present confined to testing a vein on the southeast quarter of section 34, township 66, range 34, about two miles south of Rock Harbor, by the lake shore. Its course is northeast; its inclination, 68° to the northwest. Thus, although its course is conformable to the axis of elevation, its inclination cuts across the beds of rock. The vein is thirteen inches in width, composed of calc spar, quartz, and epidote, with native copper in thin sheets adhering to the hanging-wall, and disseminated through the gangue. An adit has been started near the water-level to intersect a shaft 25 feet deep, a short distance from the shore. The rock in which it is excavated is a dark-gray, granular trap. The walls are well defined, and the character of the rock is favorable. This belt, it was feared, would not prove sufficiently thick to afford ample room for working the vein. The veinstone contains from 8 to 12 per cent. of copper, which is sufficiently rich to pay for mining.

A small feeder comes into the vein on the left, about 15 feet from the entrance to the adit, at which point it presents the following section:

Fig. 29.

1. Laumonte, 1 inch.

2. Epidote and quartz, with brecciated wall-rock containing copper in bunches and disseminated, 13 inches.

3. Fragments of wall-rock, with strings of copper in the fissures, associated with the laumonite and epidote, 4 feet 3 inches.

A few rods to the south is seen another vein about eight inches in width. The matrix consists of datholite, heavily charged with native copper. It is in a rock similar in character to that above described, resting on which is a hard, crystalline greenstone. The vein, in its upward course, becomes contracted to a mere fissure, containing little copper, where it enters the incumbent greenstone.

The following shafts have been sunk by this company, under the direction of Mr. Douglass:

One on the southeast quarter of section 22, township 66, range 34. At the depth of 20 feet, they intersected the columnar trap, a continuation of the belt described as occurring at the Siskawit mine. The vein in the upper belt was three feet wide, but after entering the columnar trap it rapidly contracted, and at the depth of 35 feet exhibited a mere seam a few lines in width.

On section 2, township 65, range 34, a shaft was sunk 40 feet; at the depth of 10 feet a belt of sandstone was struck, which continued as far as the shaft was prosecuted, forming the foot-wall of the vein.

On section 35, in the same township and range, a shaft was sunk to the depth of 90 feet. The formation dips to the southeast, while the vein inclines to the northwest.

On section 10, township 65, range 34, a shaft was sunk to the depth of 40 feet on a vein of epidote and datholite two feet in width.

These shafts, at the time of our visit, were filled with water, and we were unable to gather exact information as to the character and productiveness of the several veins.

TABULAR STATEMENT

OF

THE MINES IN THE LAKE SUPERIOR LAND DISTRICT,

IN

THE STATE OF MICHIGAN

Tabular statement of the mines in

Name of mine.	Situation.	Elevation above lake.	Nature of the rock.	Phenomena of the lode.
		Feet.		
Cliff mine, (Pittsburg and Boston Company.)	Town'p 58 north, range 32 W., sect. 36, southwest quarter.	393	A belt of amygdaloidal trap, capped with hard crystalline greenstone, the vein traversing both diagonally. It expands, and becomes highly metalliferous in the amygdaloid, but barren & pinched in the greenstone.	The lode is about 15 inches wide on the average, bearing north 27° west, with an underlie of 10° to the east. Veinstone drusy quartz, calc-spar, laumonite, prehnite, and chlorite, with native copper disseminated in spangles, bolts, and sheets. Surfaces often incrusted with green carbonate and red oxide copper. Sheet copper often fills the entire vein; one of which weighed 50 tons. Silver associated; most abundant near the junction of the two belts.
North American..	Town'p 57, range 32, section 2, northeast quarter.	415	Geological position similar to the Cliff, both being in the same amygdaloidal belt, but the veins are distinct.	The lode in the widest part is 7 feet; the average width 2½ feet. The course is north 58° west; underlie 10° to the east. The veinstone consists of calc-spar, laumonite, prehnite, chlorite, apophyllite, and drusy quartz, with copper (native) similar to the Cliff, with the exception that the masses are less abundant.
Minnesota	Town'p 50, range 39, section 15, northwest quarter.	637	Near Ontonagon river. Gray amygdaloidal trap, consisting of hornblende, feldsp'r, and ch'orite. Rock rather firm and compact, the vein running with the formation.	The lode is from 8 inches to 8 feet wide; average 3½ feet between the walls. Course north 50° east; underlie 38° to the north. Native copper in large masses and in spangles and bolts in a veinstone of calc-spar, chlorite, and epidote. Silver not rare. Fragments of the wall-rock are often found included.
Northwest	Town'p 58, range 30, section 15.	....	This mine is situated on the south'rn slope of the axis of Keweenaw point. The top of the ridge is greenstone, resting on a belt of conglomerate 12 feet thick, succeeded by amygdaloid and compact trap, which contain the veins.	There are three veins within 300 yards. East vein, north 16½° east; average width 14 inches. Middle vein, north 19° west; average width 18 inches. West vein, north 17° west; average width 12 inches. Underlie of east vein, 6° east; middle vein, 6° west; west vein, 12° west. Veinstone quartz, calc-spar, chlorite, & laumonite, investing native copper in masses, spangles, and specks. Native silver in small quantities.

the Lake Superior land district.

Depth of shafts.	Length of adits.	Drainage.	Amount of ore raised.	Per cent.	No. of men. Surface.	No. of men. Miners.	No. of shares.
I. 260 feet II. 240 feet III. 200 feet	I. 275 feet II. 361 feet III. 465 feet IV. 560 feet V. 578 feet	Effected by pumps, with horse-power, working six hours per day.	2,528 tons, at 60 p. c. Contents of vein-stone 100,000 tons=14½ p. cent.	14½	59	101	6,000
I. 215 feet II. 230 feet	I. 220 feet II. 225 feet III. 235 feet	Whim, by horse-power, working four hours per day.	1,700 tons.....	9½	61	24	6,000
I. 57 feet II. 57 feet III. 27 feet	I. 150 feet II. 180 feet	Windlass; adit intersects the vein 77 feet below surface.	57 t. in masses =60 p. cent., & 700 stamp-work=11½.	12	48	36	3,00
East vein— I. 90 feet II. 60 feet III. 72 feet Middle vein— I. 50 feet II. 42 feet West vein— I. 50 feet II. 25 feet III. 43 feet	East vein— I. 480 feet II. 190 feet Middle vein— I. 100 feet West vein— I. 340 feet	Whim, worked by horse-power 6 hrs. per day.	50 tons masses =50 p. cent.; 500 t. stamp-work=8 per cent.	12	42	53	10,000

STATEMENT—

Name of mine.	Situation.	Elevation above lake.	Nature of the rock.	Phenomena of the lode.
		Feet.		
Copper Falls....	Town'p 58, range 31, section 11, southeast quarter.	203	A belt of amygdaloid 150 feet thick, included between a band of sandstone below and conglomerate above. The vein cuts these bands diagonally. The productive portion is limited to the amygdaloid.	Lode variable in width, but its average may be assumed at 8 inches. Course north 23° west; underlie 13° west. Native copper, with considerable silver, near the junction of trap and conglomerate. One mass of copper from this vein weighed 12 tons. Veinstone similar to those before described, with the addition of analcime and mesotype.
Northwestern....	Town'p 58, range 31, section 24.	593	Geological position similar to the Northwest.	Average width of the lode 1 inches; expands in places to 4 feet. Course north 23° west; underlie slightly to the west. Native copper in sheets, bunches, and disseminated through veinstone of calc-spar, chlorite, &c.
Phœnix, (formerly Lake Superior.)	Town'p 58, range 31, sections 19 and 20.	237	Comp trap and amygdaloid, surmounted by a thin belt of conglomerate, with a hard greenstone porphyry below. The amygdaloid traversed by numerous strings of prehnite, quartz and laumonite, containing native copper and native silver.	Most of the workings here have been prosecuted off from the vein, and the bulk of the mass raised was from the west wall-rock. It consisted of amygdaloidal trap, the amygdules being filled with native copper. There are indications of a good vein here, bearing, probably, north 17° west; but the workings did not develope it.
Lac la Belle.....	Town'p 58, range 29, section 32, northeast quarter.	309	A hard crystalline rock, composed of feldspar & chlorite, with an imperfect chlorite slate at the base, resembling a volcanic ash.	Two sets of veins. One bearing north 26½° west, with an underlie to the east of 12°; variable in width; average 18 inches; not been sufficiently explored to determine its value. Veinstone calc-spar, with chlorite and quartz, including gray and yellow sulphuret of copper, with a trace of silver. E. and W. vein 6 inches wide. Course north 80° east, with an underlie of 35° to the north. Not continuous.
Bohemian........	Town'p 58, range 29, section 29, southeast quarter.	622	This mine is in the same mountain as Lac la Belle mine. The rock is similar.	Veins a continuation of those last described.

Continued.

Depth of shafts.	Length of adits.	Drainage.	Amount of ore raised.	Per cent.	No. of men. Surface.	Miners.	No. of shares.
I. 130 feet II. 42 feet III. 145 feet	I. 436 feet II. 190 feet III. 100 feet IV. 128 feet Ad. 275 feet	Whim, worked by horse-power 4 hrs. per day.	....	......	Temporarily suspended.		3,000
I. 24 feet II. 38 feet	Adit 362 feet; if driven 950, will intersect vein.	At a depth of 140 feet.	....	......	..do..	..do..	3,000
I. .. feet II. 60 feet III. .. feet IV. 75 feet	....	Whim, worked by horse-power 6 hrs. in 24.	....	......	..do..	..do..	1,200
I. 31 feet II. 48 feet III. 36 feet	I. 396 feet II. 900 feet	By adits. No. II, 27 feet above Lake Superior; I, 309 ft. above.	100 tons......	20	4	6	10,000
I. 106 feet II. 75 feet	I. 120 feet II. 20 feet	Whim, worked by horse-power.	100 tons......	3	Temporarily suspended.		2,500

STATEMENT—

Name of mine.	Situation.	Elevation above lake.	Nature of the rock.	Phenomena of the lode.
		Feet.		
Quincy	Town'p 55, range 34, section 26.	400	The vein ranges with the formation, being between two belts of trap. The upper wall brown compact trap; the lower amygdaloidal.	The lode bears north 43° east, and dips 58° to northwest; average width 8 in. Veinstone calc-spar, chlorite, and quartz. Native copper in sheets and diffused through the veinstone.
Forsyth.........	Town'p 57, range 32, section 33, southeast quarter.	554	The cap of hill is greenstone, with amygdaloidal trap at the base.	Lode well defined on surface. Course north 9½° west. Underlie 9° to east. Native copper in sheets and diffused, with abundant traces of silver. Veinstone calc-spar, chlorite, and epidote.
Albion..........	Town'p 57, range 32, section 11.	672	Geological position similar to that of the Cliff and North American.	Lode composed of chlorite, calc-spar, &c., with thin scales of native copper; 18 in. wide. Course N. 46° W. Underlie 8° to the east.
Forest	Town'p 50, range 39, section 20, southwest quarter.	650	Amygdaloidal & gray trap, vein running with the formation.	Lode quartz, chlorite, calc-spar, and epidote, with native copper in bunches and disseminated. Course north 70° east. Dip 70° north.
Ohio Trap Rock .	Town'p 49, range 40, section 5, southwest quarter.	672	Greenstone trap, the vein ranging and dipping with the formation.	Veinstone epidote, chlorite, quartz, and calc-spar, with native copper disseminated. Course north 52° east. Dip 39° north.
Adventure........	Town'p 58, range 38, section 35, southwest quarter.	....	Hard close-grained trap—an unkind rock.	Vein pinched and ill-defined, bearing southwest, and dips north. Native copper in bunches in chlorite, epidote, and quartz.
Isinglass Houghton.	Town'p 51, range 37, section 15, northwest quarter.	478	Compact chlorite trap, the vein conforming to the general direction of the range in bearing and inclination.	The lode bears north and south, with an inclination of 60° to the west. Veinstone quartz and chlorite, with copper disseminated and in bunches.
Pittsburg and Isle Royale.	Town'p 65, range 36, section 12, northwest quar-	20	Hard greenstone, with conchoidal fracture.	Vein pinched, expanding downwards; 18 inches in width in places. Course north 20° east. Dip 78° west. Native copper in sheets and grains, with calc-spar, prehnite, &c.
Siskawit	Town'p 66, range 34, section 13, southwest quarter.	60	Dark compact trap, with columnar trap 40 feet below surface.	Vein bears east and west. Underlie 15° to the north. Veinstone epidote, chlorite, calc-spar. Native copper in sheets and disseminated.
Ohio and Isle Royale.	Town'p 66, range 34, section 34, southeast quarter.	25	Dark-gray, granular trap, capped with greenstone.	Vein composed of epidote, calc-spar, with native copper, bearing northeast. Dip 68° to northwest.

Continued.

Depth of shafts.	Length of adits.	Drainage.	Amount of ore raised.	Per cent.	No. of men. Surface.	Miners.	No. of shares.
I. 67 feet	....	Windlass.....	6 tons........	3	Temporarily suspended.		3,000
I. 70 feet II. 36 feet III. 10 feet	....	Windlass.....	20 tons.......	6	..do..	..do..	3,000
I. 100 feet II. 40 feet III. 38 feet	I. 70 feet II. 60 feet	Windlass and adit.	6 tons........	4	..do..	..do..	40,000
I. 21 feet II. 13 feet	....	Whim.........	Not fully tested.	......	8	10	6,000
I. 108 feet II. 40 feet	I 250 feet	Adit and windlass.	75 tons.......	4	Temporarily suspended.		10,000
I. 24 feet II. 13 feet	I. 30 feet	Adit.........	7 tons........	6	2	6	10,000
....	25 feet	....	10 tons.......	8	4	8	6,000
I. 63 feet II. 67 feet	I. 42 feet II. 113 feet III. 18 feet	Windlass.....	50 tons.......	10	4	20	6,000
I. 40 feet II. 35 feet	115 feet	Whim.					
25 feet	I. 40 feet	Windlass.....	10 tons.......	9			

We have thus attempted to give, somewhat in detail, a description of the several mines now wrought in the Lake Superior land district. We have endeavored to exhibit the principal phenomena of the veins, their range, extent, and metallic contents.

When it is considered that nearly the entire copper region is an unreclaimed wilderness, the miners' settlements appearing like mere dots on its surface, covered with a dense growth of trees, through which the explorer with difficulty forces a path; and that, except where the streams have worn their beds in the rock, or the hills terminate in bold and craggy ledges, the ground is covered with a thick carpet of mosses and lichens, effectually concealing every trace of veins,—it is surprising that such an amount of mineral wealth has been revealed within so short a period. This region had occasionally been traversed by the trapper, and the white man had coasted along its rock-bound shores, at intervals, for nearly two hundred years; but up to the year 1841, when Houghton made his reconnaissance, we have no evidence that a really productive vein had been observed. To him is to be ascribed the credit of having first pronounced on the value of this region for mining purposes, and delineated, with a graphic pen, its geological outlines.

It is only about a year since the Minnesota mine, which is surpassed by none in the region either in extent or productiveness, was developed. The same is true, to a great extent, of the North American.

As the country becomes opened, and the means for exploration become increased, new sources of mineral wealth will undoubtedly be revealed. There will be an increase in the products of these mines from year to year, until the national supply will exceed the national consumption.

For certain purposes in the arts this copper stands unrivalled; in density and tenacity it surpasses all the ores of copper. Hence, in the manufacture of wire, where extreme ductility is required—in the manufacture of ordnance, where tenacity is the chief requisite—this copper should be employed. It would be proper for the government, in contracting for ordnance, with the double view of encouraging this branch of industry and securing an article made of the best material, to insert a stipulation that they be cast from this copper. The same encouragement might be given in sheathing the national ships.

This copper contains a small per centage of silver—too inconsiderable in most cases to justify separation, but the presence of which enhances the value of the copper, protecting it, in a considerable degree, from the corrosive action of salt water. These qualities, when known, will give it a preference in market over copper reduced from the ores.

We have estimated the product of the copper mines for the year 1849 at 1,200 tons. For the ensuing year it may be safely rated at 2,000 tons; and a proportionate increase may be anticipated for several years to come.

How far the product of these mines will go towards supplying the home demand may be inferred from the following table, which exhibits pretty accurately (at least as much so as any statistics which are available) the extent of that demand:

Statement, furnished by the Register of the Treasury, exhibiting the value of copper unmanufactured annually imported during the ten years ending June 30, 1849.

Years.	In pigs, bars, &c.	In plates suited to sheathing.	Old copper fit only for remanufacture.	Ore.	Total value.
1840..............	$1,100,664	$411,567	$70,405	....	$1,582,636
1841..............	1,054,469	535,473	91,869	....	1,681,811
1842..............	821,109	381,197	82,195	....	1,284,501
1843..............	369,076	244,050	47,641	$64,148	724,915
1844..............	488,981	688,610	79,805	56,485	1,313,881
1845..............	1,095,230	738,936	81,264	48,807	1,964,237
1846..............	1,038,461	840,815	114,833	98,156	2,092,245
1847..............	1,491,209	1,043,572	*	....	2,534,781
1848..............	702,907	831,848	*	158,302	1,693,057
1849..............	988,683	1,044,755	*	177,736	2,211,174

By this statement it will be seen that the average value of copper annually imported into the United States slightly exceeds $1,708,000. Assuming the price of pig copper to be 18 cents per pound, and sheathings to be 22 cents, the annual consumption would be less than 5,000 tons. The product of the Lake Superior mines for the year 1851 will probably reach one-half of this amount, or 2,500 tons. There is a limit to the productiveness of all mines; for, when once fairly opened, their exploitation becomes more expensive the farther it is prosecuted. That limit has not been attained by any of the mines of Lake Superior.

We have endeavored in the subsequent pages of this chapter to bring together a mass of statistical information with regard to the products of mines in different countries, which may be useful for reference to those engaged in public pursuits, as well as the general reader.

* Old copper included with copper in pigs.

The following table of the metals annually raised in Great Britain and Ireland is taken from De la Beche's Survey of Cornwall, (1836,) but is probably too low for the present time:

Iron	£8,000,000
Copper	1,200,000
Lead	920,000
Tin	390,000
Manganese	50,000
Silver	30,000
Zinc	7,000
	£10,597,000

M. Verlet (Gen. and Stat. Rev., 1837) furnishes the following comparative statement of the yield of the different mines of Europe, taking Great Britain for a unity:

Great Britain	1
Russia and Poland	$\frac{2}{7}$
France	$\frac{1}{4}$
Austria	$\frac{2}{13}$
Spain	$\frac{1}{8}$
Prussia	$\frac{1}{6}$
Sweden	$\frac{2}{19}$
Harz	$\frac{1}{12}$
Tuscany	$\frac{1}{31}$
Bavaria	$\frac{1}{35}$
Saxony	$\frac{1}{34}$
Piedmont and Savoy	$\frac{1}{38}$
Denmark	$\frac{1}{49}$
Norway	$\frac{1}{35}$

It will thus be seen how largely the mining interest of Great Britain preponderates over that of any other nation of Europe.* Russia, the principal seat of whose mining operations is in the Ural mountains, ranks next in the scale. The productiveness of these mines is yearly increasing, and the relative preponderance of Great Britain is yearly diminishing. France, whose mines are conducted with the most consummate skill, occupies the next place on the list.

Our own country abounds in mineral wealth. Our coal-fields, occupying portions of fourteen States, comprehend an area of 130,000 square miles. Associated with them are extensive beds of iron, rivalling in richness those of Shropshire and Wales. Numerous furnaces and foundries have already sprung up along the lines of their out-crop, giving employment to a large number of operatives. The high price of labor and the remoteness of the beds from the seaboard have operated to depress this branch of business, which employs a capital of more than $20,000,000.

The Silurian limestones of the West, while they support a soil of great fertility, yield an amount of lead beyond the national consumption.

*The number of persons directly dependent on mining operations in Great Britain is estimated at 1,000,000: 193,000 are actually employed in the mines.

The value of the copper mines and their influence on the national wealth, we have attempted to set forth.

The richness and extent of the gold tracts of California surpass all of our previous knowledge of this class of deposites, and seem fabulous rather than real. It is to this region, also, that we can confidently look for a supply of quicksilver.

The zinc ores of New Jersey are beginning to be advantageously wrought. It is extremely difficult to obtain a correct statement of the mining interest of the United States, as there is no statistical bureau to which those interested in this branch of industry are required to make returns. The census returns hitherto have been very imperfect. The following table can be regarded only as an approximation to the value of metals annually raised in the United States:

Gold	$40,000,000
Iron	16,500,000
Lead	2,400,000
Copper	750,000
Mercury*	500,000?
	$60,150,000

The mining interest of this country is in its infancy. If the products of the California mines are as great as has been represented by those who have had the best opportunities for acquiring information, the United States at the present time is the most prolific in metallic wealth of any of the nations of the earth. The great chain of the Andes is protracted beyond the northern limits of Oregon, though on a scale less magnificent than in South America. It is composed essentially of the same rocks; and we may therefore confidently expect to find a recurrence of the same mineral products which characterize it in Peru and Chili. Thus far, in regard to its mineral wealth, it may be regarded as comparatively unexplored.

To show the products of the mines in different countries, we have prepared the annexed table, from the most authentic sources within our reach. With regard to the South American mines, our materials are very deficient. The unstable character of the governments, the imperfection of the custom-house returns, and the amount of precious metals annually smuggled out of those countries, all render these statistics little better than estimates. The mineral produce of China is undoubtedly great; but it is all consumed within her own borders, and has, therefore, no effect upon the market. The same remark is applicable to other Asiatic countries.

*It is said that the quicksilver mines of California are now yielding a profit of $3,000 daily; but we apprehend that this statement must be received with many grains of allowance.

Table showing the product of mines throughout the world, so far as known.

Countries.	Gold.	Silver.	Mercury.	Tin.	Copper.	Zinc.	Lead.	Forged iron.	Pig iron.
	Pounds—Troy.		Pounds.	Cwt.	Tons.	Tons.	Tons.	Tons.	Tons.
Great Britain		16,000		88,600	14,000	2,500	56,000	2,200,000	
Russian Empire	70,000	43,000			4,100	3,000	2,450	102,000	180,000
France		5,000			100		450	303,700	416,200
Prussia and Customs Union	100	94,000		6,900	1,500	18,000	9,350	75,000	110,000
Austrian Empire	3,400	215,000	661,500	1,200	4,500	500	3,500	150,000	
Belgium						7,500	5,000	90,000	
Sweden and Norway	15	25,000			1,500		60	87,000	115,000
Denmark								6,400	
Spain		50,000	2,240,000	2,000	1,000	200	31,000	220,000	180,000
Sardinia		750					200	9,000	
Tuscany and Elba			20,000		400			10,000	
Turkey					2,000				
United States	100,000		160,000		2,000		26,000	500,000	
Cuba					6,000				
Mexico	10,000	1,400,000							
Brazil	13,800								
Peru	3,000	370,000	50,000		500				
Buenos Ayres	1,500	325,000							
Chili	7,000	215,000			5,000				
Columbia		800							
Australia					2,000				
Banca, Malacca, &c				100,000					
Japan					2,400				

According to the estimates of M. Leplay, secretary of the Commission of Mining Statistics in France, the whole amount of copper produced in the world is equal to 52,400 tons. This, however, does not include portions of the Asiatic continent—with regard to which we have no statistical knowledge, but of which the mineral produce is entirely consumed within its own borders. According to the same authority, this amount of copper is consumed in the following manner:

	Tons.
Great Britain	10,600
France	9,200
German Customs Union	5,400
Austrian Empire	2,600
Russian Empire	2,000
Sweden and Norway	400
Other States of Europe	6,600
America [United States 5,000]	6,100
Asiatic continent (India and Oceanica)	8,300
Japan	1,200
Total	52,400

CHAPTER V.

ANCIENT MINING.

Evidence of ancient mining, excavations, implements.—High antiquity to be ascribed to them.—Whether they can be traced to the mound-builders.—Ancient works at the Minnesota mines.—At the Forest mine.—Nature of the materials found in the pits.—Bones.—Evidences of tumuli.—Extent of these workings in the Ontonagon region.—On Keweenaw Point.—On Isle Royale.—May they not be traced to the aborigines?

That this region was resorted to by a barbaric race for the purpose of procuring copper, long before it became known to the white man, is evident from numerous memorials scattered throughout its entire extent. Whether these ancient miners belonged to the race who built the mounds found so abundantly on the Upper Mississippi and its affluents, or were tho progenitors of the Indians now inhabiting the country, is a matter of conjecture.

When all of the facts shall have been collected, the question may be satisfactorily determined. The evidence of the early mining consists in the existence of numerous excavations in the solid rock; of heaps of rubble and earth along the courses of the veins; of the remains of copper utensils fashioned into the form of knives and chisels; of stone hammers, some of which are of immense size and weight; of wooden bowls for bailing water from the mines; and numerous levers of wood used in raising the mass copper to the surface.

The high antiquity of this rude mining is inferred from the fact that the existing race of Indians have no tradition, by what people or at what period it was done. The places, even, were unknown to the oldest of the band until pointed out by the white man. It is inferred from the character of the trees growing upon the piles of rubbish—between which and those forming the surrounding forest no perceptible difference can be detected—from the mouldering state of the wooden billets and levers, and from the nature of the materials with which these excavations are filled, consisting of fine clay, enveloping half-decayed leaves, and the bones of the bear, the deer, and the caribou. This filling up resulted, not from the action of temporary streamlets, but from the slow accumulations of years.

Traces of tumuli, constructed in the form of mathematical figures, have been observed, but not sufficiently explored to determine absolutely whether they be the work of art, and, if so, for what purposes they were intended.

It is well known that copper rings, designed for bracelets, are frequently met with in the western mounds. We have several of these relics in our possession. There is no evidence that the race by whom those structures were built possessed sufficient knowledge of the metallurgic art to reduce and purify the ores of copper. Admitting that they did, should we not naturally refer to this region, instead of seeking a more remote one, as the source from which these materials were derived? Are not these copper

rings a strong link in the chain of evidence to connect the ancient mining of this region with the earth-works of the Mississippi valley?

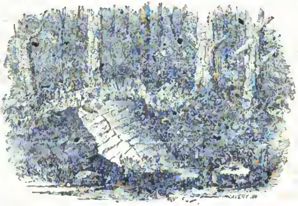
We will now proceed to the details of the discoveries thus far made. The most extended excavations are found in the vicinity of the Ontonagon river; and to Mr. Samuel O. Knapp, the intelligent agent of the Minnesota Company, belongs the credit of having first laid before the public an account of their nature and extent.

In the winter of 1847–'48, while passing over a portion of the location now occupied by the Minnesota Mining Company, he observed a continuous depression in the soil, which he rightly conjectured was caused by the disentegration of a vein. There was a bed of snow on the ground three feet in depth, but it had been so little disturbed by the wind that it conformed to the inequalities of the surface. Following up these indications along the southern escarpment of the hill, where the company's works are now erected, he came to a longitudinal cavern, into which he crept, after having dispossessed several porcupines which had selected it as a place of hybernation. He saw numerous evidences to convince him that this was an artificial excavation, and at a subsequent day, with the assistance of two or three men, proceeded to explore it. In clearing out the rubbish they found numerous stone hammers, showing plainly that they were the mining implements of a rude race. At the bottom of the excavation they found a vein with ragged projections of copper, which the ancient miners had not detached. This point is east of the present works.

The following spring he explored some of the excavations to the west, where one of the shafts of the mine is now sunk. The depression was twenty-six feet deep, filled with clay and a matted mass of mouldering vegetable matter. When he had penetrated to the depth of eighteen feet, he came to a mass of native copper ten feet long, three feet wide, and nearly two feet thick, and weighing over six tons. On digging around it the mass was found to rest on billets of oak, supported by sleepers of the same material. This wood, specimens of which we have preserved, by its long exposure to moisture, is dark-colored, and has lost all of its consistency. A knife-blade may be thrust into it as easily as into a peat-bog. The earth was so packed around the copper as to give it a firm support. The ancient miners had evidently raised it about five feet and then abandoned the work as too laborious. They had taken off every projecting point which was accessible, so that the exposed surface was smooth. Below this the vein was subsequently found filled with a sheet of copper five feet thick, and of an undetermined extent vertically and longitudinally. The position of the copper block, and the extent of the exploitations along a portion of the lode, may be seen by reference to the plan of the Minnesota mine, on page 133. The vein was wrought in the form of an open trench; and where the copper was the most abundant, there the excavations extended the deepest. The trench is generally filled to within a foot of the surface, with the wash from the surrounding surface intermingled with leaves nearly decayed. The rubbish taken from the mine is piled up in mounds, which can readily be distinguished from the former contour of the ground.

A few rods to the west is another specimen of ancient mining, where

Fig. 30.

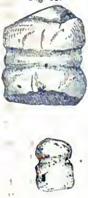


they have left a portion of the veinstone standing, in the form of a pillar, in order to support the hanging wall. The rubbish in this excavation has not been cleared away, so that its extent is unknown.

These evidences are observed on this location for a distance of two and a half miles. Upon a mound of earth we saw a pine stump, broken fifteen feet from the ground, ten feet in circumference, which must have grown, flourished, and died since the earth in which it had taken root was thrown out. Mr. Knapp counted three hundred and ninety-five annular rings on a hemlock, growing under similar circumstances, which he felled near one of his shafts. Thus it would appear that these exploitations were made before Columbus started on his voyage of discovery.

The amount of ancient hammers found in this vicinity exceeded ten cart-loads, and Mr. K., with little reverence for the past, employed a portion of them in walling up a spring. They are made of greenstone or porphyry pebbles, with a groove, single or double, cut around, by which a withe was attached. The following is a sketch of one of the larger class, the dimensions of which were $12 \times 5\frac{1}{2} \times 4$ inches, and the weight $39\frac{1}{2}$ pounds. The smaller class, weighing five or six pounds, were probably wielded in one hand. The annexed sketch will convey an idea of their form.

Fig. 31.



In addition to these relics, a copper gad, with the head much battered, and a copper chisel, with a socket for the reception of a handle, were brought to light. It contained the fragment of a wooden handle, when discovered, which crumbled very soon after being exposed. The timber in the excavation before described showed the marks of an axe, the bit of which must have been about two inches in width.

Mr. Wm. H. Stevens, the agent of the Forest mine, has discovered other workings on the southwest quarter of section 30, township 50, range 39, almost of equal extent and interest. They occur on the southern slope

of a hill, and consist of a series of pits, some of which, on being opened, are found to be fourteen feet deep. They are arranged in four lines, following the courses of four veins or feeders.

In cleaning out one of these pits, at the depth of ten feet the workmen came across a fragment of a wooden bowl, which, from the splintry pieces of rock and gravel imbedded in its rim, must have been employed in bailing water.

Remnants of charcoal were found, not only there, but at numerous places, lying on the surface of the rock. Some have supposed that fires were kindled for the purpose of melting the copper, but the more reasonable supposition is that heat was employed to destroy the cohesion between the copper and the rock. Before the introduction of gunpowder, fire was the great agent in excavating rock; and even now, in the Harz and at Altenberg, two of the old mining districts of Europe, this agent is employed to break down rocks of extreme hardness. It is quite as economical where fuel abounds as gunpowder in destroying silicious rocks.

We can hardly conceive it possible for them to have made such extensive excavations with such implements simply as they have left behind, without availing themselves of the aid of fire.

In one of these pits—southwest quarter of section 35, township 51, range 38—were found the bones of a deer, in a pretty good state of preservation. Fragments of the cranium, humerus, and of one horn (which, to use the language of sportsmen, was in the "velvet" at the time of the destruction of the animal) were taken out. The smaller bones had mouldered away. They reposed on clay, a foot above the surface of the pit, and were covered with accumulations of clay, leaves, gravel, and sand to the depth of nineteen feet. It would appear that the animal either fell into the pit or ventured in to procure water, and, unable to extricate himself, perished.

These pits, filled as they were with water, would not become the dens of carnivorous animals, and to no agency of theirs are we to attribute the position of these bones.

In the northeast quarter of section 16, township 50, range 39, near a small stream, there is a mound which has the appearance of having been the work of art. Mr. Hill, from whose notes much of the above information has been derived, states that from the want of tools he was unable to penetrate it, to determine whether it was stratified or not. It is about ten feet high, in the form of a square, the sides of which are fifteen feet in length, flat on the top, and slope regularly to the base.

Fig. 32.

There is another tumulus on the right bank of the Ontonagon river, six miles above its mouth, forty feet high, and nearly circular, which has been supposed to be artificial, but has not been explored with a view to determine the point.

From the northeast quarter of section 31, township 51, range 37, to section 5, township 49, range 40, a distance of nearly thirty miles, there is almost a continuous line of ancient pits along the middle range of trap, though they are not exclusively confined to it.

Upon Keweenaw Point they have been found extending from Eagle river eastward to range 28, a distance of twelve miles, along the base of the trap range. A great number of hammers were discovered on the

present site of the Northwest Company's works, which first led the explorers to suspect the existence of a valuable lode of copper. They have also been found at the Copper Falls mine, and at the Phœnix, formerly the Lake Superior, mine. At the latter place a copper knife was discovered, in the early explorations of that tract.

Mr. C. G. Shaw pointed out to us similar evidences of mining on Isle Royale. They occur on what is known as the Middle Finger, and can be traced lengthwise for the distance of a mile. Mr. Shaw remarks that, on opening one of these pits, which had become filled up with the surrounding earth, he found the mine had been worked through the solid rock to the depth of nine feet, the walls being perfectly smooth. At the bottom he found a vein of native copper eighteen inches thick, including a sheet of pure copper lying against the foot-wall.

The workings appear to have been effected simply by stone hammers and wedges, specimens of which were found in great abundance at the bottom of the pits. He found no metallic implements of any description, and is convinced, from the appearance of the wall-rocks, the substances removed, and the multitude of hammers found, that the labor of excavating the rock must have been performed only with the instruments above named, with the aid perhaps of fire. From the appearance of the vein and the extent of the workings, he conjectures that an immense amount of labor had been expended. He endeavored to find some evidences of the antiquity of these workings, but could discover nothing very satisfactory to his own mind, except that they were made at a remote epoch. The vegetable matter had accumulated and filled up the entire opening to a level with the surrounding surface; and, in a region where it accumulates as slowly as it does on the barren and rocky parts of Isle Royale, this filling up would have been the work of centuries. Upon this vegetable accumulation he found trees growing equal in size to any in the vicinity.

All will admit that the facts above set forth assign to these excavations a high antiquity; but whether they were made by a race distinct from the Indians now inhabiting the region, is a matter of extreme doubt, although all traditions with regard to their origin have perished.

A race like the Indians, dependent principally on hunting and fishing for the means of subsistence, would employ copper, where it was accessible, in the construction of their weapons of capture, in preference to stone, it being more easily fashioned and less destructible. This would naturally be expected in the rudest and most simple state of society.

Among the earliest benefits derived from their contact with the whites would be the introduction of iron implements, which would soon supersede those of copper. They then would have no interest in maintaining a communication with the copper region, which abounded in few animals of the chase, or in preserving among their tribe a knowledge of the places from which the metal was obtained. The lapse of a century or two would obliterate all traditions. We have seen that the first missionaries arrived on the borders of Lake Superior as early as 1641, and it is probable that the tribes which they there found had established an intercourse with the whites at Quebec and Montreal years before. If, from the scanty records of the Jesuits, we could gather what amount of skill was displayed by the savages in the art of making metallic implements, and the kind of material used, it would throw much light upon this point.

Skulls form the most distinguishing feature between the several tribes of the human family; and hence their discovery—which may be looked for among these excavations—will afford authentic testimony of the character of the race by which they were made.

NOTE.—According to Kalm, (Reise, th. 3, s. 416,) M. de Verandrier, who in 1746 was sent upon an overland expedition intended to reach the Pacific, by Chevalier de Beauharnois, then governor-general of Canada, in the prairies 900 miles west of Montreal, found enormous masses of stone, placed in an upright position by the hand of man, and on one of them was something which was taken to be a Tartar inscription. It was engraved on a small tablet which had been let into a pillar of cut stone, in which position it was found. Some of the Jesuits in the city of Quebec assured Kalm that they had seen and handled the supposed inscription. It was afterwards transmitted to Count Maurepas, in France. Humboldt, from whom we derive this information, (Aspects of Nature, title Steppes and Annotations,) adds: "I have asked several of my friends in France to search out this monument, in case it should really be in existence, and in the collection of Count Maurepas, but without success." May not this carved stone have been the work of the old copper-miners? Verandrier further affirmed that, throughout entire days' journeys, traces of the ploughshare were discernible; but Humboldt remarks that "the total ignorance of the primitive nations of America with regard to this agricultural implement, the want of draught cattle, and the great extent of ground over which the supposed furrows are found, all lead to the conjecture that the singular appearance has been produced by some effects of water on the surface."

The surface of the island of Mackinac, which lay in their route, presents the appearance of a ploughed field. It arises from the removal of blocks of stone from their place of bedding in the strata by the agency of water, during the drift epoch. The earth is not evenly distributed, but lies in ridges like graves, and well might be mistaken for the remains of aboriginal tillage.

CHAPTER VI.

VEINS AND VEINSTONES.

The occurrence of copper in different parts of the earth.—Geological association.—Definition of veins.—Different systems.—Length, width, and underlie.—Their gangues and the changes which they undergo in their passage through different mineral planes.—Formation of veins.—Materials composing their gangues, and the order of arrangement.—Comby structure.—Position of the silver and of the mass copper.—Veins of native copper, an anomaly.—Various hypotheses as to the mode of filling.—Injection.—Sublimation.—Electro-chemical agency.—Universal diffusion of magnetism, and its influence on the combinations of matter.

Before entering upon the detailed description of the phenomena of the veins of the Lake Superior district, it would be proper to consider the conditions under which copper occurs in other portions of the earth, and thus afford the means of comparing this newly-discovered district with those in which veins have been wrought for centuries. We shall then be able to appreciate the peculiar, and we may say unique, character of the Lake Superior district, and arrive at some general conclusions as to the degree of importance to be attached to the facts developed in the progress of the explorations.

It must not be forgotten how short a time has elapsed since the first attempts at mining were made, and the physical obstacles which had to be overcome before the business was established on a firm basis. Although on the eastern continent mines have been wrought from time immemorial, and every year has added some new facts to the mass already collected, yet the theory of veins, their detailed structure, and the relation of the various ores to their gangues and the enclosing walls can only be said to be imperfectly understood in those districts where the most skill and science have been devoted to their investigation. It cannot, then, be expected that we shall be able to solve the various problems presented in the investigation of so complex a subject in a district where mining explorations have been carried on only a few years, and where a small portion of our time only could be devoted to the collection of the facts brought to light.

The occurrence in this district of powerful veins of native copper in igneous rocks is a deviation from the general rules found to prevail elsewhere. They are confined, as we have seen from the detailed geology, to the *bedded* trap, while the rocks of the preceding epoch—for instance, as at the Prince mine, Mamainse, and other places on the Canada shore, where the greenstones have flowed over the slates—are characterized by the presence of veins of the sulphurets.

In referring to the conditions under which copper occurs in other regions, we will commence with Cornwall—a district best known to the American miner. This district furnishes all of the tin and seven-eighths of the copper mined in Great Britain. There are about 112 veins wrought,

at an annual expense of £900,000. The rock in which they are principally developed is clay slate, or *killas*, as it is termed by the Cornish miners, constituting the base of the Silurian system, among which the granites and elvans have been protruded. The ores are the yellow sulphuret of copper and iron, with which are associated, in the undecomposed part of the vein, black sulphuret, red oxide, and native copper. The gangue of the cupriferous veins is almost exclusively quartz. The average of the ore raised does not probably exceed two and one-half per cent, but by dressing it is brought up to eight per cent.

France at present affords but one workable mine of copper. Numerous mines have been wrought at various periods, but at this time they are abandoned. In the Vosges, the copper veins are associated with the argillaceous slates of the carboniferous era, among which porphyritic rocks have been protruded.

The celebrated mines of Chessy, in central France, are at the junction of the granite and lias.

Germany.—In the Harz mountains, the copper veins, with quartzose gangues, occur in gran-wacke slate, with intercalated belts of trappean rocks. The product of these mines does not exceed 300 tons. The mines of Rheinbreitenbach, in the same formation, are productive in pyritous and variegated copper, accompanied by a gangue entirely quartzose.

In the vicinity of Mansfeld, in Prussia, occurs the interesting deposite known as the "kupferschiefer," or copper slate—a thin layer in the zechstein, throughout the whole thickness of which is disseminated gray argentiferous copper ore, yielding about 2.1 per cent.

Near Schemnitz, in Hungary, is an interesting metalliferous region, which produces about 5,000 tons of copper annually, together with gold, silver, antimony, and other metals. The veins are included in porphyritic rocks, which are connected with sienites, passing into granites. The predominating gangues are quartz and sulphate of baryta; the ores, pyritous and gray copper.

Spain.—The general character of the deposites of the metals in Spain is similar to those of the Harz. The amount of copper raised is trifling, compared with that of lead and mercury.

Norway and Sweden.—The sulphuret of copper and iron is almost the only ore obtained from the Scandinavian mines, and is very meagre, rarely exceeding 3 or 4 per cent. The Norwegian copper is highly esteemed, in consequence of its freedom from arsenic and other metals.

The veins are principally confined to the gneiss and mica slate. The famous mine of Fahnlu, now nearly exhausted, occurs in the latter rock. From 1838 to 1843, the Norwegian and Swedish mines did not yield over 1,500 tons of pure copper.

Russia.—The Russian copper deposites in the Ural mountains are remarkable for the purity and richness of the ores, with which is associated considerable native copper. They have been compared to the veins of Lake Superior, but between the two districts there are few points of analogy. The most productive mines are those of Tourinsk and Nijnytagilsk.

The chief mining-ground at the last-named places is a broken and unconsolidated mass of detritus, containing thin veins and nests of malachite. It lies in the depressions worn in the surface of the upturned edges of the limestone strata belonging to the upper portion of the Silurian

rocks, among which are intermixed broken ridges of amphibole rock. The malachite is unquestionably a secondary product, resulting from a cupriferous solution, deposited in a stalagmite form. Such is the character of the Russian deposites.

Cuba.—The average product imported to England from 1843 to 1847 was 5,400 tons of pure copper—the average yield of the ore being a little over 16 per cent. The copper deposites of Santiago are highly productive. The ores are not in regular veins, but in beds and masses, subordinate to the igneous rocks, especially greenstone and serpentine. The gangues are quartz, dolomite, and carbonate of lime. The yellow sulphurets are associated with the hydrated oxide of iron. Native copper is also observed in this connexion. The presence of native silver in the blue carbonate of copper is by no means rare.

Chili.—The average quantity of copper smelted in Wales, from the ores and black metal from this source, from 1843 to 1847, was 4,400 tons. The average yield of the ore and black metal was 31.15 per cent.

The copper veins are exceedingly numerous and powerful, and exist in the granite. The gangues are quartzose and jaspery.

Australia.—These mines, though worked but a few years, are daily rising in importance. The geological association of the rocks is similar to those of Cornwall. Hills of mica slate compose the Barrossa district; and distorted clay slate, like the *killas* of Cornwall, is seen in the Adaline district. Through these the granites and sienites have protruded. The ores of copper are abundant, consisting of the red oxide and sulphurets.

From the verbal communications of Sir John Richardson, we infer that the analogy between the Lake Superior deposites and those of the Coppermine river is very marked. The rocks consist of bedded trap and sandstone, with occasional layers of limestone, traversed by veins containing native copper and malachite.

It will thus be seen that the ores of copper are confined to no particular position in the geological column, but range from the lias to the granite. Veins are the principal repositories of most of the valuable metals employed in the arts, and, whether observed in the Ural or the Harz, in Cornwall or on the borders of Lake Superior, exhibit certain features in common—showing that their formation is due to the operation of general laws.

They are almost always found associated with the igneous and metamorphic rocks; but where they occur in rocks purely detrital, the igneous rocks are generally found not far removed. It is, therefore, to igneous agency that we are to attribute the formation of fissures and the seggregation of their metallic products.

Mr. Carne remarks: "By a true vein, I understand the mineral contents of a vertical or inclined fissure, nearly straight, and of indefinite length and depth."

Werner, the great Saxon geologist, defined veins as "mineral repositories, of a flat or tubular shape, which traversed the strata without regard to stratification, having the appearance of rents or fissures formed in the rocks, and afterwards filled up with mineral matter which differed more or less from the rocks themselves."

A true vein, therefore, may be defined as a fissure in the solid crust of the earth, of indefinite length and depth, which has been filled more or less perfectly with mineral substances, introduced by various agencies,

subsequent to the formation of the fissure. They differ essentially from beds, which are generally contemporaneous with the formation in which they are enclosed, and range and dip with the associated rocks. This distinction cannot in all cases be recognised, since mineral deposites sometimes present characteristics common to both.

Every mining district exhibits certain systems of veins, which differ from each other in age, and often in their mineral contents.

In Cornwall, three sets have been observed, which have been designated by certain provincial appellations well understood: 1st. The system of *right-running* veins, which traverse the country in a direction nearly east and west. Mr. Henwood found, as the mean of 300 observations, that the right-running veins containing metalliferous ores bore 4° north of east and south of west.

Another set, called *contras*, intersect the main veins at an angle of 45°; and still another set, called *cross-courses*, intersect the *right-running* veins at nearly right angles. The first system is the most ancient, because it is always traversed by the other two; they are the older tin veins. The next are those which contain tin and copper. The third are the east-and-west veins, which are the most recent and the most productive of copper.*

These veins vary from one to four feet in width. They ordinarily extend a few thousand feet, and some even a mile; the great vein of the United mines has been, however, traced to the distance of eight miles.

The direction of the principal veins in Mexico—for instance, the *Veta Grande* and *Veta Madre*—is northwest and southeast, and they are exhibited on a scale of grandeur unknown in the mining districts of Europe. Thus the *Veta Madre* has been traced continuously on the surface for more than six miles, and expands in places to the enormous width of ninety feet.

In the Cerro de Pasco, Peru, noted for its silver ores, one set of veins, according to Tschudi, bears north and south, which is intersected by another set bearing east southeast and west-northwest. The *Veta de Colquirica* has been traced to the distance of nine thousand six hundred feet, and it expands to the width of four hundred and twelve feet. This belongs to the first-mentioned class. The *Veta de Pariarirca*, which belongs to the second class, is known to extend six thousand four hundred feet in length, and three hundred and eighty feet in breadth. From these large veins, numerous small ones branch off in various directions, forming a complete network of silver beneath the surface.

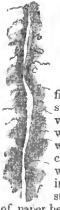
A vein of two or three feet in width can probably be as economically wrought as one of much greater expansion; the ores are more concentrated, and the expense of securing the work by timbers is proportionately less.

Veins of Keweenaw Point.—On Keweenaw Point, one system of veins is well defined. Their bearing is north of west—the mean of several observations giving north 21½° west. So true is this, that no permanently productive vein has been discovered thus far which varied 15° from this course, which is at nearly right angles to the formation, or axis of upheaval. These veins, in their downward course, deviate more or less from a perpendicular, amounting to 8° or 10°, or even 12°. They also expand

* Ansted on Mining, Lecture XV.

and contract at short intervals, which results from the lateral and vertical dislocations to which the walls have been subjected. The Cliff vein affords an illustration of this kind, a section of which is subjoined:

Fig. 33.



a. Walls nearly in contact.
b. Vein nearly vertical, displaying two layers or combs—seen in the fourth level north of the main shaft.
c. Veinstone, brecciated; east layer only seen; vein pinched and much inclined.
d. East layer now seen.
f. Vein perpendicular, and expanding in width.

Not more than one half of the east comb is represented in the fissure. The miners call it a "splice in the vein." These splices will be found to occur wherever the vein becomes nearly vertical. They fill the vein just above the points where the walls nearly come in contact, and run out on the overhanging wall, leaving the west comb to occupy the more inclined and contracted parts of the fissure. The brecciated veinstone is always found just above the points where the walls nearly come in contact. These expansions and contractions in the vein result from a vertical dislocation of the enclosing walls. If a piece of paper be cut in a waving, irregular line, and one part slipped beyond the other, it will represent pretty correctly the irregularities of a vein. The surfaces of the fissure, or rather the walls, are polished and striated, resulting from the repeated slippings of the mass.

Veins in the Ontonagon region.—A different system of veins prevails here. The veins run with the formation, instead of cutting it at right angles, like those of Keweenaw Point. In the St. Agnes, Gwennap, Redruth, and Camborne districts, in Cornwall, according to De la Beche, the general coincidence of the lines of bearing of the tin and copper lodes with the lines of elvans is particularly remarkable.

In describing the peculiarities of the trappean rocks, we stated that whenever they approached the detrital rocks, as a general thing, they assumed a stratiform appearance; and this remark is applicable to this region. The fissures appear to have been formed along these lines, and correspond in bearing and underlie to the bearing and dip of the associated sedimentary rocks.

Of this class of veins, the Douglass Houghton, the Forest, and the Minnesota are marked examples. Some have supposed, from the coincidence in the bearing and underlie of these fissures with those of the sedimentary rocks, that they were of contemporaneous origin—in fact, that they were simply beds. We do not, however, regard them in this light. Take, for example, the Minnesota vein. The walls are polished and striated, and the mineral matter composing the gangue is distinct in character from the enclosing rock. The vein exhibits numerous strings and feeders, and, wherever these intersect it, marks of derangement are observable. The veinstone is arranged in combs, like that of the vertical fissures. These peculiarities are sufficiently marked to justify us in regarding them as true veins.

There is another class of deposites whose course and underlie correspond to the course and dip of the adjacent sedimentary deposites. We regard them as beds, contemporaneous with the associated rocks. They differ from the fissures last described in these particulars: They are im-

perfectly defined, there being no clear lines of junction with the walls; are very irregular in their course, exhibiting nothing like parallelism for a considerable distance; and the mineral matter with which the copper is associated is never arranged in combs or lamellar plates. They are known as "epidote veins," the gangue consisting of epidote and quartz, with native copper. They appear to be the result of seggregation, rather than injection, and are as rich at the surface as at any given depth. This class of beds is generally associated with the quartzose porphyries of the region west of the Ontonagon river and the Porcupine mountains.

Numerous explorations of these beds have been made, but in no instance successfully.

The quartzose porphyries are also traversed by a set of narrow irregular fissures, nearly vertical, filled in with quartz, and for the most part barren of copper.

In this connexion, we may mention still another class of deposites. Between the trappean and detrital rocks is often interposed a bed of chlorite, three or four feet in width, through which copper is found disseminated in small bunches. The Union mine, now abandoned, on the Little Iron river, at the base of the Porcupine mountains, is an illustration of this kind.

Veins of Isle Royale.—The veins of Isle Royale are more complicated than those of the districts we have before described. There are several systems, but the explorations have not been sufficient to enable us to determine their relative ages.

One system of veins bears nearly east and west, corresponding with the bearing of the associated sedimentary rocks; but while the former dip to the northwest at an angle of 75°, the latter dip to the south-southeast at an angle of 12° or 14°. To this class belong the Siskawit and Scovill vein and the Duncan vein, on section 34, township 66, range 34, on the lease of the Ohio and Isle Royale company.

Another class may be appropriately called beds, having a bearing and dip conformable to those of the detrital rocks. This class is seen near the head of Rock Harbor, and at a place on the southern shore of the island which bears the classical appellation of Epidote.

There is another system of fissures which run nearly north and south, at right angles with the axis of elevation, and dip from 10° to 20° to the east. To this class may be referred the vein now wrought by the Pittsburg and Isle Royale Company at Todd's Harbor, and the powerful vein on Phelps's island, at the outlet of Washington Harbor. Numerous fissures holding the same course may be seen between Siskawit bay and Rock Harbor.

Few veins exhibit their true character on the surface, which arises probably from the oxidation of the materials composing the gangue. Owing to the nature of the country, it is impossible to trace the veins continuously for any considerable distance; but we have satisfied ourselves that some continue six, and even eight miles. They rarely exceed four feet in width. The average width of the best veins thus far developed does not exceed two feet. Few faults have as yet been observed to interrupt their continuity.

Having thus endeavored to define the different systems of veins in this region, we will next consider *their gangues, or materials composing the*

veinstone, as well as the changes which they undergo in their passage through different rocks.

The gangues of veins deserve to be closely scrutinized by the miner, since a knowledge of their peculiarities is of great practical importance in enabling him to judge of the probable productiveness of a vein. The gangues of the most productive veins in this region consist of an admixture of calc-spar, chlorite, epidote, laumonite, and drusy quartz. Prehnite, fluor-spar, analcime, datholite, mesotype, apophyllite, and table-spar are occasionally met with; but their presence may be regarded as accidental. In no instance has a purely spar vein been found productive. The same remark will apply to the quartz veins.

In other countries, the miner judges of the character of the lode by the character of the veinstone. Thus, in Cornwall, above the veins where rich deposites of copper occur is a mass of ferruginous matter, called by the miners *gossan.*

In the Harz, a red oxide of iron, known as *chapeau de fer*, caps the lead and silver ores, and when struck affords the miner almost unerring indications of the proximity of rich deposites.

It is deemed unnecessary here to describe the character of the veinstones with more minuteness, inasmuch as detailed information will be found under the appropriate head in the *Table of Mines.*

The productiveness of a vein is also influenced by the character of the enclosing rock. Where it exists in the greenstone or hard crystalline rock, it is pinched; where it enters the soft porous amygdaloid, it becomes scattered and ill defined; and in its passage through a belt of conglomerate, it almost always ceases to be metalliferous.

The most favorable rock—that in which a vein is best developed—is a granular trap, with occasional amygdules scattered through it of a lively color, and possessing a good degree of firmness.

This kind of rock belongs to the bedded trap. No veins of native copper have been found except in this association.

The influence of the enclosing rock upon the productiveness of a vein, and the change in its mineral contents in passing through different belts of rock, have been observed in other regions.

"Granite, or its modification, elvan," remarks De la Beche, in his Survey of Cornwall, "is found near all the localities where tin and copper ores so abound as to be worked and produce good mines; while lead, antimony, manganese, iron, and zinc are discovered in sufficient quantities to be profitably raised at a distance from granite or elvan. As far as the two counties of Cornwall and Devon are concerned, the conditions favorable for tin and copper ores seem unfavorable for those of lead. Valuable mines in the granite become worthless when they pass into the slates."

In the Harz, according to M. Fournet, veins passing from argillaceous slate into cherty slate lose their productive character. Hard granites, as a general thing, are less prolific than the soft decomposed kinds.

To show the changes which veins undergo in their passage through different beds of rock in this district, a few examples will be cited.

We have described the range of hills in which the Cliff and North American mines are situated as composed of crystalline greenstone at the summit, and a granular trap, somewhat amygdaloidal, at the base. The same remark will apply to the Northwest and Northwestern mines. In

the greenstone the veins are contracted and barren, but on entering the granular trap they become expanded and give evidence at once of their true character.

At the Copper Falls mine, the vein in the northern trap belt was well defined and productive; but on entering the belt of sandstone to the south, it contracted to a mere fissure. This belt was perforated, but the miners did not succeed in recovering the vein in the southern trap belt. (*Vide* section of the works in the chapter on mines.)

Mr. Hill traced a vein which appears near the lake shore by Copper Harbor through successive belts of conglomerate and trap, and thus describes the changes: This vein is on sections 25 and 36, township 59, range 29, and township 58, range 29. It is distinctly marked on the surface through the above-named sections, and can be examined every few yards on the line of bearing. It varies but little in its general course from north to south, and underlies slightly to the east. Its width in the first belt of sandstone and conglomerate is two feet, and its gangue consists of calc-spar, with some native copper. Its width in the first trap belt is 14 inches, and its gangue consists of calc-spar and laumonite, with native copper disseminated. In the main range of conglomerate it expands to two and a half feet, and is filled in with calc-spar, and exhibits no trace of copper.

The large spar vein known as the "Green Rock" among the early voyageurs, which strikes the shore at Hays's Point, Copper Harber, is undoubtedly a continuation of the black oxide vein a few rods east of Fort Wilkins. In the first conglomerate belt, the spar was associated with the green and blue silicates of copper. In the second conglomerate belt, it contained, in addition to the silicates, large masses of black oxide of copper.

In the bottom of the harbor, when the water is tranquil, a spar vein, destitute of copper, is seen in the included trap, corresponding to the direction of the vein in the conglomerate on either side.

Thus there can be little doubt that the veins of Keweenaw Point traverse different mineral planes, and, in their passage through them, undergo marked changes in their gangues and metallic contents.

On Isle Royale, the veins exhibit the same changes. Mr. Shaw sank a shaft on a vein, above Scovill's Point, to the depth of ninety-six feet. For thirty feet the rock was soft, in which the vein was well developed, expanding in places to four feet in width, and containing considerable copper. At that depth a band of columnar trap was struck and penetrated to the depth of sixty-six feet. The vein contracted to a foot in width, and was nearly barren and worthless.

Mr. Whittlesey, the former agent of the Siskawit mine, informed us that, at their works, the columnar trap was intersected at the depth of thirty-five feet; that the vein was well exposed in the overlying amygdaloidal trap, but that on entering the columnar trap it narrowed to a mere fissure.

The same results followed the explorations on section 27, township 66, range 34, belonging to the Ohio and Isle Royale Company.

On section 33, township 67, range 33, a vein bearing north 50° east, the gangue of which consists of quartz, chlorite, and calc-spar, with considerable native copper, is seen traversing a trappean rock composed of hornblende and feldspar, highly crystalline. Mr. Shaw sank on this vein

to the depth of fifteen feet, when he intersected a dark hornblende trap, in which the vein lost its character and became worthless.

The most striking illustration of the changes of a vein in its passage through different mineral planes is to be seen on the northwest coast of this island. The cliffs consist of numerous alternations of greenstone

Fig. 34.

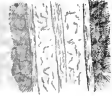
and porphyry, which are cut by a vein varying from a few inches to two feet in width. The upper portion of the vein at *a*, is made up of trappean matter; a few feet lower down, at *b*, the gangue is entirely quartzose; still lower it gives place to calc-spar. It may be seen in the annexed figure; *p*, *p*, *p*, represent bands of porphyry; *d*, the lowest band of porphyry seen, which is amygdaloidal, the cavities being filled with calc-spar, below which point this substance entirely fills the space betweeen the walls, indicating a common origin of the calcareous matter both of the vein and the porphyritic band. The bands of phophyry are separated from the trap by thin layers of laumonite.

Formation of veins.—The manner in which veins occur would seem to indicate that they were rents or fissures formed subsequently to the consolidation of the different mineral planes. The parallelism exhibited in the same system of veins would further indicate that their direction had been determined, not by fortuitous circumstances, but by the operation of general laws.

The materials composing the gangue of veins are often arranged in parallel plates, constituting what the Cornish miners call *comby* lodes. De la Beche supposes that this arrangement resulted from successive openings of the fissure.

The following is a section of the gangue of a vein on the southeast quarter of section 10, township 60, range 39, Isle Royale:

Fig. 35.



1. Laumonite, half of an inch.
2. Prehnite, with native copper, two inches.
3. Clay, probably decomposed chlorite, one inch.

This vein appears to have been subject to three successive openings.

The east vein of the Northwest Company exhibits two combs: that attached to the foot-wall, six inches in width, is composed of calc-spar with little copper; that attached to the hanging-wall, twelve inches in width, consists of chlorite, quartz, and calc-spar, investing copper in spangles and masses.

We have given sections of several veins in the chapter on mines, and they may be referred to in the further illustration of the structure of the veins of this region.

In the Cliff vein, there are two combs—that attached to the foot-wall containing most of the masses, while the other carries disseminated copper.

The sheets of native copper, as a general thing, though not invariably occupy the foot-wall of the vein.

Where crystals occur investing the walls, with their faces opposite,

whether separated or interlocked, they afford strong presumptive evidence of the orginal width of the fissure.

The Prince vein, Canada shore, affords a beautiful illustration of this. The vein on Spar island is about fourteen feet in width, the walls being invested with amathystine quartz, with the faces turned outwards, occupying two feet in width, while the intermediate space is filled in for the most part with calc-spar and pyritous copper.

It is difficult to determine the order in which the materials composing the matrix of veins were deposited. In some cases the earthy substances were deposited before the metallic, and in others it is evident that copper existed in the fissures before the process of filling was complete. It is probable, however, that the copper was formed at different times.

At the Copper Falls mine, for example, we find small specks of copper enclosed in obtuse rhomboidal crystals of calc-spar, variously modified; again, we find native copper deposited *around* crystals of analcime and calc-spar, taking the form of the faces of the crystals, every line and wave being faithfully represented, as in the electrotype process. The copper often appears in arborescent forms, invested with calc-spar.

The Prince mine affords specimens of dog-tooth spar, studded with minute crystals of bi-sulphuret of copper, while the vitreous copper is often enclosed in a matrix of carbonate of lime.

The silver in this vein is found in thin leaves, between the laminæ or joints of the crytrallized spar, indicating that it was deposited subsequent to the filling of the vein.

At the Minnesota mine it is not unusual to find spongiform copper adhering to the walls, which would seem to indicate that copper was the first substance deposited in the fissure. Again we find it deposited in thin plates between the joints of the crystallized quartz, which would indicate that the latter was deposited subsequent to the former. We have before us a specimen from this mine, consisting of native copper, native silver, crystallized quartz, and carbonate of lime, (calc-spar.) The copper and silver are distinct, and appear to be chemically pure. The form of the crystals of quartz is impressed on the silver and copper, and in the body of the crystals there is no trace of a metallic substance. The calc-spar, however, conforms to the silver and copper, both of these metals being disseminated through it. The silver occurs in imperfect octohedra of the size of a pea.

This arrangement would seem to indicate the following order in the deposition of the materials: 1. Quartz; 2. Copper and silver; 3. Calc-spar.

At the Cliff and North American mines perfect crystals of copper occur only in the cavities of the matrix; when in contact with quartz, it takes the form of this substance.

The inference from these facts is, that some of the earthy materials constituting the veinstone were deposited prior to the copper and silver, while others were subsequent in their deposition.

The silver is generally found to occupy a certain position in the lode. Thus, at the Copper Falls mine, it is most abundant near the junction of the trap and conglomerate on the north; at the Cliff mine, near the junction of the crystalline greenstone and granular trap. Although silver is intimately associated with the copper, yet it does not occur in sufficient quantity to justify the expense of separating the two metals. The lodes are frequently brecciated the angular fragments evidently having been de-

rived from the adjacent walls—and are most abundant above the points where the fissure is nearly closed.

Mode of formation.—Having endeavored to set forth the principal phenomena of the veins of the Lake Superior district, we propose to advert to the principal theories which have been advanced to explain the method by which the process of filling has been accomplished.

Native copper is often found in veins abounding in sulphurets, but under circumstances very different from what are observed in the Lake Superior district. Its presence is thus described and explained by De la Beche.* Beneath the gossan, which results from decomposition of the ore, we observe appearances strongly reminding us of the common electrotype process for procuring copper from a solution of sulphate of copper. The pure metal is gathered together in chinks and cavities between the main mass of gossan and the body of the undecomposed copper pyrites, mingling perhaps with the lower part of the former. Sometimes this native copper, as it is called, may retain its metallic character; but at others it becomes converted into an oxide, and this again into a carbonate, by the percolation of waters containing common air and carbonic acid.

It is probable that the sulphur, by a union with the needful oxygen, became sulphuric acid, and that, this formed, the copper was attacked and removed, to be dealt with like any other solution of the sulphate of copper.

Three theories have been suggested to account for the filling of veins:

1st. That the foreign matter has been injected in a molten state, and afterwards slowly crystallized.

2d. That the volatile matters have been slowly sublimed from below by heat, and condensed upon the walls of the fissure.

3d. That the materials were once held in aqueous solution, and precipitated by electro-chemical agency.†

1. *Injection.*—We can hardly conceive it possible that the copper, in a fluid state, has been forced up from below like dikes of porphyry or greenstone. It is well known that, in many of the loftiest volcanoes, the column of lava does not rise to the lip of the crater, but breaks through the sides of the mountain. An elastic force sufficient to raise a fluid mass of three times the density of lava would shatter the enclosing walls, and force the copper into the fissures. If this were its origin, we ought to find it occupying the depressions in the surface rocks in the vicinity of the fissures, like modern lava currents.

We find the copper investing various crystallized minerals, and every wave and stria of the pre-existing crystals is faithfully represented. It is impossible, by any artificial method, to cast any metal so as to exhibit such minute lines. They are as delicate and faithful as could be obtained by the electrotype.

Again, the associated minerals do not exhibit the effects of a high temperature. These consist of zeolites, which yield potash, soda, and lime, and hold a large percentage of water of combination, and of carbonate of

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* Admirality Manual, title Mineralogy.

† In those veins which are widest near the surface, and gradually contract in their downward progress, the foreign matter has been undoubtedly introduced from above; and even in those veins which increase in width as they descend, occasional fragments derived from the surface have been met with. Thus Carne states that, at the Relistran mine, Cornwall, quartz pebbles, cemented by oxide of tin and bisulphuret of copper, have been found at the depth of 600 feet in a tin lode. The black oxide vein at Copper Harbor belongs to this class.

lime, (calc spar and andalusite,) and earthy silicious minerals, (quartz, agates, &c.)—all of which may be supposed to have resulted from the precipitation of aqueous solutions, rather than from fusion under pressure.

Again, if the contents of the veins were the result of injection, their productiveness would be unaffected in their passage through different mineral planes.

Lastly, copper and silver combine in indefinite proportions, forming a homogeneous compound; and yet we find them existing side by side almost chemically pure. Admitting that they once formed a homogeneous compound, it is reasonable to infer that they have been separated by electro-chemical agency.

2. *Sublimation.*—This theory explains some of the phenomena of mineral veins which the preceding theory does not. Thus, in some veins, crystals of earthy materials line the walls, whose under surfaces are studded with minute metallic particles, while the upper surfaces are quite smooth.

Iron glance is formed at this day in fissures on the margins of the craters of Vesuvius and Stromboli. The volatile particles are raised by heat, and condensed on the sides of the fissure in crystallized forms. The parallel arrangement of the different materials on the sides of the vein may also be explained by this hypothesis. The artificial production of various crystals—such as feldspar, hornblende, mica, and magnetic oxide of iron, found in the slags of furnaces, and of garnets, rubies, idocrase, and olivine, formed in the laboratory of the chemist—have also been relied on as affording direct evidence of sublimation.

The minerals thus artificially produced, however, belong to a different class from those which accompany the native copper.

This hypothesis does not explain the changes which are exhibited by veins traversing different rocks, nor the substitution of different metals in the same vein, chemically distinct.

The fact that copper, silver, and lead have been found deposited on timber and leaves in some of the long abandoned mines of Europe proves that heat is not the only solvent power by which these metals may be made to assume new forms.

3. *Electro-chemical agency.*—There is but little doubt that magnetic currents are in a continual state of slow but regular change, sweeping round the two hemispheres. Ampere was the first to announce that these currents traversed the earth from east to west; and others have applied them in explanation of the chemical changes which have taken place in lodes during the process of their formation.

The observations of Mr. Robert Were Fox, in the Philosophical Transactions and the Proceedings of the Geological Society of Cornwall, upon the electro-magnetic properties of veins, and of Becquerel, in his "Traite de l'Electricite," upon the artificial production of crystallized insoluble compounds of copper, lead, and lime, throw light upon one of the obscurest pages in the history of the earth; yet it must be confessed that these experiments have not revealed all that was anticipated at the time of their promulgation. M. Becquerel shows that, by the long continued action of weak electrical currents, many crystallized subtances hitherto found only in nature may be artificially obtained.

Mr. Fox, by placing copper wires against two portions of a lode, or of two lodes divided by a cross-course, and connecting the wires with a gal-

vanometer, was enabled to detect a current of electricity. The needle was observed to deviate in some cases to such an extent that it was impossible to note the deflection. In nearly all of the mineral veins of Cornwall he was enabled to detect these currents, but in Teesdale the results of his experiments were negative. He was successful in procuring an electrotype copy of an engraved plate, by a current collected from two lodes of iron and of copper pyrites, and also in inducing magnetism in a bar of soft iron.

Professor Reich detected very decided currents in the lead and silver veins near Freyburg; but Von Strombeck on the other hand, could obtain no results in the copper and lead lodes of the Rhine.

Mr. Robert Hunt made also numerous experiments in the mines of Cornwall, and almost invariably obtained indications of electricity—in one case so powerful that electro-chemical decomposition was produced. He also examined these currents in reference to their connexion with the general currents which traverse the earth, according to the theory of Ampere, and was induced to conclude that they were local, and due to the chemical action going on in the lode itself. They were often found to traverse the lode contrary to the general currents which sweep round the earth, and often at right angles to them.

He inferred that these local currents had had a powerful effect upon the masses of matter exposed to their influence, although the formation of veins might not originally have been due to their agency.

The amount of muriate of soda (common salt) which he had found in the waters of many of the deep mines of Cornwall, equalling in some cases nine hundred and fifty grains in a cubic foot, had, in his opinion, acted powerfully in inducing chemical changes in the lode.*

The existence of two metals side by side, like copper and silver, each chemically pure, and capable of being alloyed in any proportions; the accumulation of the latter near the cross-courses, or at the junction of two mineral planes; the changes in the metallic contents of lodes in their passage through different rocks; and the parallel arrangement of the earthy gangues,—all seem to indicate the existence of electrical currents during the period of their formation.

It is to magnetism—an agency subtle, but universal and all-powerful, pervading every particle of matter, and operating unceasingly—that we are to look for an interpretation of many of the obscurest passages in the history of the earth.

To use the beautiful figure of Humboldt: "That which forms the invisible but living weapon of the electric eel; that which, awakened by the contact of moist dissimilar particles, circulates through all the organs of plants and animals; that which, flashing from the thunder-cloud, illumines the broad canopy of the sky; that which draws iron to iron, and directs the silently-recurring march of the guiding-needle,—all, like the several hues of the divided ray of light, flow from one source, and all blend again together in one perpetual, everywhere-diffused force."†

* Lecture on the electricity of mineral veins, before the Royal Institution, London.

† Aspects of Nature, vol. 1, art. 1.

CHAPTER VII.

METALLURGY

Purity of Lake Superior native copper compared with refined copper from various smelting-works.—Specific gravity.—Occurrence of silver in connexion with it.—Method of separation.—Liquition.—Amalgamation.—Mechanical separation.

The term *metallurgy* is applied to the art of extracting the various useful metals from their ores, so as to furnish them to the manufacturer and consumer in such a state of purity as may be required in the various uses to which they are applied in the arts.

The processes by which copper is reduced from its combination with iron and sulphur in the ore, from which the greater portion of that metal is extracted, are long and tedious; nor is the skill of the smelter sufficient to separate the copper in a perfect state of purity and freedom from other metals which impair its value. On the contrary, the copper of commerce contains considerable quantities of iron, lead, nickel, and other metals, as is shown by the following analyses of refined copper from various districts:

	I.	II.	III.
Copper	98.655	98.251	
Iron	.055	.131	0.17
Nickel	–	.236	
Lead	.751	1.092	
Silver	.226	.135	
Potassium	.116	–	0.38
Calcium	.095 }	.107	0.33
Magnesium	.033 }		
Aluminium	.021	.048	
Silicium	.048		
	100.00	100.00	

No. I is Swedish copper.

No. II is Mansfeld copper, analyzed by V. Kobell.

No. III is Swiss copper, analyzed by Berthier.

Native copper from Brazil, having a specific gravity of 8.962, contained iron, 0.17; calcium, 0.38; magnesium, 0.33.

Japanese copper is said to be perfectly pure; also the native copper from the Siberian mines, according to G. Rosé.

The native copper from the Lake Superior mines may be considered to be chemically pure. It dissolves in pure nitric acid without leaving a trace of residuum; it gives no precipitate when the nitric acid solution is heated with ammonia; neither on the addition of chloro-hydric acid. It dissolves to a clear solution in concentrated sulphuric acid when heated; it contains no trace of arsenic or other volatile metal. This is the result of the examination of several specimens of copper from the Phœnix, Cliff, and Minnesota mines. A piece of copper from the last-named mine, sawn

with care from a perfectly pure and solid mass, was found to have the specific gravity of 8.838. The density of pure copper is given by different authors as follows:

Peligot and Frèmy, pure fused copper	8.78
Berzelius, " "	8.83
Scheerer and Marchand, " "	8.921
Scheerer and Marchand, copper in fine wire	8.952

It has been asserted that some of the native copper contains a small portion of silver alloyed with it. This may be the case; but we have not found any silver in the specimens which we have examined, when no particles of that metal were visible in the mass.

The method of occurrence of the native silver in connexion with the copper in the Lake Superior region is one of the most novel and striking features in the distribution of the metallic riches of that district. Native silver occurs by no means unfrequently, at various points of the trap range, from one extremity of the district to the other. It has, however, been found in the greatest quantity at the Phœnix, Cliff, Copper Falls, and Minnesota mines; the largest specimen hitherto obtained was taken from the workings of the Phœnix (formerly Lake Superior) Company's mine. It was a rolled, detached lump, perfectly pure, which weighed over six pounds, and is now in the collection of the mint at Philadelphia. This mass was found in a large excavation or pot-hole worn by the action of the stream in passing over the course of the vein, and filled with the debris of the vein and the adjoining rocks, and numerous masses of copper and silver derived from the ruins of the veinstone. Several thousand dollars' worth of the latter metal were taken from this hole. In the various excavations on this location, numerous specimens of silver associated with copper have been obtained, both in the vein, where they generally occur associated with prehnite, and in the adjacent rock, either in bunches and strings, or sometimes in almost invisible particles.

A specimen of native silver from the Minnesota mine was found to contain no other foreign substance than a trace of copper. A specimen from the old Lake Superior Company's mine contained no copper, but a small quantity of iron.

The silver and copper do not, however, in general, occur alloyed with each other, as would naturally be supposed on the theory that they have been forced up together in a state of fusion from the heated interior of the earth. The silver is scattered through the metallic copper in such a manner that each metal remains entirely free from alloy with the other, although the junction of the two at their edges is a perfect one. The silver is often interspersed in the mass of copper, so as to form a species of porphyry, the former metal occuring in small patches and particles perfectly soldered to the enclosing mass of copper, yet, chemically speaking, entirely distinct from it. The native silver seems to occur especially in connexion with a soft greenish magnesian mineral, also with calcspar and prehnite, and has never, so far as we know, been found distinctly crystallized, as the copper often is.

The only question of any practical difficulty in regard to the metallurgic treatment of the Lake Superior copper is that of the occurrence of the native silver in connexion with the copper.

If there should be a large amount of silver found finely intermixed

with the copper, so that it could not be mechanically separated, it would be important to decide how the two metals could be separated in the most economical manner, and how small a percentage of silver could be economically worked. If the percentage of silver in the copper is large, a separation of the two metals can be effected by the use of acids in the humid way. The so-called "aqua regia" was many years since used by Keir, in England, for separating metallic silver from copper. It consists of a mixture of concentrated sulphuric and nitric acids, or oil of vitriol, mixed with one-tenth its weight of saltpetre. By this reagent the silver is dissolved, and the copper only very slightly acted on.

In the separation of silver from copper, when both the ores of these metals occur in combination, in the Harz, the method called *liquation* is resorted to. In this operation the argentiferous copper, which may contain as low as 0.0016 per cent. of silver, is fused, in the state of black copper, with between two and three times its weight of lead and litharge, and cast into large flat disks, which are then ready for the liquation furnace. In the treatment by this furnace the lead containing the silver flows off into the well in front of the hearth, whence it is taken with ladles and cast into ingots. The silver is then separated from the lead by cupellation.

At Tsiklova, in the Bannat, the silver contained in the black copper is separated by amalgamation. The ores are principally argentiferous mispickel mixed with copper pyrites. The black copper obtained by three separate processes of fusion, contains from 80 to 90 per cent. of copper, with from 0.00125 to 0.00375 per cent. of silver.

This is heated to the highest point possible without its fusing, and then pulverized by stamps. The pulverized substance is then mixed with 10 per cent. of common salt and a little sulphuret of iron, and heated in the reverberatory furnace. The resulting chloride of silver is then amalgamated with mercury, by means of a suitable apparatus—the reduction of the silver being effected by copper, which at the same time converts the small portion of chloride of copper which had been formed in the process of chloruration into bichloride of copper. The amalgam is then distilled, so that no mercury is lost in the operation; and the copper is fused and refined.

Up to the present time, the quantity of silver occurring with the copper in the Lake Superior region has not been sufficient to render it worth while to erect the furnaces and make the required outlay for separating these two metals; but, should the number of mines be much increased, and the quantity of silver obtained be considerable, it will be expedient to make suitable preparation for separating this metal. At present, at the Cliff mine, the particles of silver which are so flattened by the stamps as to be easily seen, are separated by hand, the coarse metal from the stamps being picked over with care for that purpose. The silver occurring only occasionally, and then often in masses of considerable size, there can be no doubt that a very considerable amount is purloined by the miners, who seem to consider the silver found in the vein as their property.

The small quantity of silver which may remain with the copper becomes, in the operation of smelting, alloyed with it, and undoubtedly improves the quality of the metal.

Taking into view what has already been said in the preceding chapters on the occurrence of the copper in the mines of Lake Superior, it is evi-

dent that the practical questions involved in the working of this region are exceedingly simple, and that few mining districts occur where mines can be opened with such facility, and their products converted into money with so little outlay of capital or skill in their metallurgic treatment.

The greater portion of the copper produced in the world is obtained from the combinations of that metal with sulphur, and principally from the ore commonly called copper pyrites, or sulphuret of copper and iron. In addition to the mechanical preparation of such ores, they require a long and complicated process to free the copper from the accompanying foreign substances, the theory of which may be thus briefly summed up:

1. *First roasting or calcination.*—This process is performed either in peculiar furnaces or in roasting pits or heaps. By it the greater portion of the sulphur is oxidized; the metals are converted into basic sulphates, which remain mixed with the portions of the ore which have escaped oxidation.

2. *First fusion or melting for coarse metal.*—Silicious substances are added, if necessary, in sufficient quantity to take up the iron, which combines it together, to form silica of the protoxide of iron, making a fusible slag; the sulphuric acid is reduced to sulphur, and the oxide of copper to copper, and sulphuret of copper is formed. The heavy combination of sulphur and copper sinks to the bottom of the furnace, while the light slag floats on the surface. This sulphuret of copper still contains considerable sulphuret of iron.

3. *Second roasting or calcination of coarse metal.*—The mass obtained by the last process is now broken up, and again roasted for several weeks in peculiar furnaces. The object of this operation is to oxidize the copper.

4. *Second fusion.*—The ore is again fused, with the addition of silicious substances, if necessary—the object of which treatment is to take up the portion of iron which still remains. The copper obtained by this process still contains many impurities: it is called black metal.

5. *Refining.*—The copper is fused and subjected to a process by which the foreign metals present in it are oxidized, and form a crust on the surface of the fused mass, which is constantly skimmed off. The copper is treated in this way till it acquires the properties of the pure metal, when the operation is suspended. It is then cast in ingots, or cooled upon the surface by throwing on water, and removed in successive flat masses, called rosettes.

This is the general description of the processes by which the ores are treated, though the details vary much in different countries and under different circumstances. The number of distinct processes which the ore undergoes in the great smelting establishments of Swansea is at least ten, which are entirely distinct from each other.

The sulphurets of copper there require a long and expensive process for smelting—a process which demands the highest metallurgic skill, and a large amount of capital. Eight companies have the control of the great Welsh furnaces, where so large a portion of the copper used throughout the world is smelted.

The question arises then, Are the sulphurets of copper destined to form an important part of the production of the Lake Superior mines?

The occurrence of the sulphurets of copper in the Lake Superior region is by no means a very uncommon fact. Two localities have furnished

ground for mining operations—one of which has been entirely abandoned; the other is temporarily suspended, though it is believed that the mine is not considered by the proprietors as entirely proved. The ore in each of these cases is mostly the black sulphuret. The yellow ore is found in comparatively small quantity, associated with the variegated. We do not believe that appearances thus far indicate that any *ore* of copper exists in the Lake Superior region in sufficient quantity to be worthy of being worked. We have, therefore, a comparatively simple task to discuss the metallurgy proper of this district, since nature furnishes us with the pure metal, associated with easily-fused veinstones, from which it can be separated by the simplest of processes—fusion.

The native copper is considered by the miners as coming under three distinct heads, according to its state of subdivision in the rock, and the size of the pieces of the metal. They are as follows:

1st. Mass.
2d. Barrel-work.
3d. Stamp-work.

1. *Mass.*—In stopeing, when a large sheet of copper occurs in the vein, the rock is removed from one side of it, and it is thrown down by means of a sand-blast, and thus lies or stands upon the bottom of the level or drift. Masses have been detached from the vein which were estimated to weigh 60 or 70 tons, mostly of solid copper, in an irregular, flattened, tabular shape, now expanding to a width of from 2 to 3 feet, and then contracting to a few inches, but firmly united. Of course, such a mass is too large to be moved in the level or raised to the surface, and it is of importance that as little of the process of subdivision as possible should be done under ground, since the operation, which must necessarily last a long time, impedes the work in the mine, and is less conveniently executed in a narrow, confined space, where easy access cannot be had to the mass on all sides, and where it cannot be readily moved. The use of powerful machinery and tackle for elevating masses of several tons' weight will be gradually introduced, when their occurrence may be reckoned upon as forming a considerable part of the value of the mine. The process of dividing the masses, at present, is as follows, and is the same, whether above and below the surface: A groove or channel is cut diagonally, at a convenient point, where the copper is as pure as possible, and the thickness comparatively small, which is carried through the mass till it is separated into two parts. To effect this, one person holds a chisel, the cutting edge of which is about three-fourths of an inch in width, and of varying length, according to the thickness of the mass to be divided; another person strikes with a heavy sledge, and at each blow the chisel is sunk into the groove and moved laterally so as to prevent its becoming wedged, until at last a chip of copper is taken out several inches in length. A repetition of this process at length completely severs the metallic mass. If the copper be perfectly pure, the operation proceeds rapidly and regularly; but when quartzose matter is to be traversed by the chisel, the labor is more tedious, and requires greater care. The cost of this operation is from $6 to $7 per square foot of surface cut through. No other process than this, tedious and expensive as it may seem to be, has yet been resorted to for dividing the masses. If the blocks were of pure copper, and not liable to contain bands and nodules of silicious mat-

ter, it is probable that a machine might be contrived for performing the operation by a kind of saw, driven by steam-power, somewhat similar to that used in dividing railroad bars. Taking into consideration, however, the difficulty just mentioned, it seems doubtful whether any more economical or efficacious means can be contrived than that which is already in use. It has been suggested that fusion of the masses might be effected, so as to divide them in that manner; but the fact that copper is so good a conductor that it would be impossible to confine the effect of the heat to a limited space and obtain a temperature high enough to produce fusion at a particular point seems to render any such method inapplicable.

The greatest thickness of a solid mass of copper, without seam or break, observed by us, was two feet four inches. This was at the Cliff mine. At the Minnesota, there appeared to be a solid mass in the vein, at least five feet in thickness.

When the masses have been brought to the surface, they are still further subdivided, if necessary, into blocks varying from one to two tons in weight—such as may be conveniently transported to the lake, whence they are shipped to market. The Boston and Pittsburg (Cliff) Company have erected a furnace at Pittsburg for fusing these masses—the details of which, however, the trustees do not allow to be made public. There is no practical difficulty whatever in the way of obtaining the copper at once perfectly pure. The veinstone consists generally of fusible minerals, such as prehnite and the zeolitic minerals, or of quartz and calcareous spar, which flow readily together. In the report of the trustees of the Pittsburg Company the per centage of the mass is estimated at 60 of pure copper in 100.

2. *Barrel-work.*—This is the name given at the Lake Superior mines to the smaller masses of copper, which are too large to go under the stamps, and too small to be shipped separately. It includes masses of copper in bunches and string-like forms, which are firmly bound together with a greater or less amount of the veinstone, and weighing from a few pounds up to several hundred. These smaller masses are picked out from the matter raised to the surface, and dressed by the hammer, so as to free them, as much as possible, from the adhering rock or veinstone.

They are then barrelled up in stout casks, which hold from five to eight hundred pounds of metal and rock. These are smelted by the Pittsburg Company, with the larger masses. The barrel-work at the Cliff mine is estimated at 50 per cent of pure copper.

The proportion of barrel-work to stamp-work furnished by the Cliff mine will be seen by reference to the table appended to the account of that mine, under the head of "Mines and Mining."

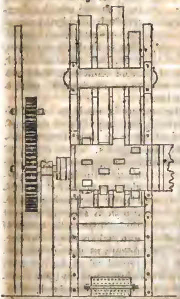
3. *Stamp-work.*—This includes all the veinstone with metallic copper in sufficient quantity to allow of its being separated by the process of washing after the stamping. The limit of the quantity of copper contained in the rock which may be profitably stamped and washed, we cannot yet fix with certainty This depends on a variety of circumstances: as, for instance, the price of labor, the economical arrangement of the works above ground, and, especially, the construction of the washing apparatus. The great difference in the specific gravity of the veinstone and the metallic copper—the former being from 2.7 to 3.5, the latter nearly 9—renders a perfect separation of the two very easy, and requires a much less complicated and scientific arrangement of the machinery

than in those cases where the ore is only a little heavier than the gangue. Of course, as the country becomes settled, and the price of labor falls, and greater method is introduced into the works, a rock containing a smaller per centage of copper may be profitably worked.

Before the rock is stamped, it is necessary that it should be roasted, in order that the veinstone, especially the quartz, may be rendered friable, so that it will readily yield to the blows of the stamps. The roasting is effected in the open air. The rock containing the copper is arranged in alternate layers with billets of wood, and then fired, and allowed to smoulder for forty-eight hours. The heat should not be carried sufficiently far to cause any portion of the copper to be fused. If necessary, water may be dashed upon the heap while still hot, to aid in destroying the cohesion between the particles of the rock.

The price of fuel is so low that this method will undobtedly be employed, although a more economical one might probably be devised.

Fig. 36.

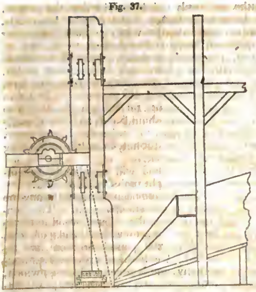


After having been calcined, the ores are taken to the stamping-mill. This consists of several pestles of wood in a vertical position, to which heads of iron, weighing 200 pounds or more, are attached. A cylindrical axle revolves horizontally, and is armed with cams, which, acting successively, catch into the shoulders of the pestles and raise them to the required height, when they are disengaged and fall into an oblong cast iron trough, which is fed with ore from a hopper above. Three or four pestles compose a battery, and several batteries are usually employed in a stamping-mill. Figures 36 and 37 represent the arrangement and form of the stamps used at the Cliff mine—the former being a front view of a single battery with four pestles, while figure 37 is a section showing the manner in which the ore and water are introduced.

An attempt was made at the Cliff mine to stamp the ore dry, and also at the Lake Superior Company's works to pulverize it by a pair of crushing-wheels; but it is satisfactorily demonstrated that the Lake Superior ores can be stamped only by the aid of water.

After stamping, comes the much more difficult process of washing the metal from pulverized rock, so that every particle may be separated without loss. As the present methods of washing practised on the lake are very imperfect, we add an account of the most approved machinery for that purpose used in the French and German mines.

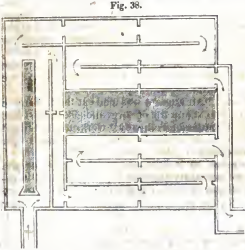
Fig. 37.



The most simple method of washing is by agitating the metalliferous sand in a bucket, by hand, imparting to it a rotatory motion, so that the lighter particles of earthy matter may be thrown over the top, while the heavier ones containing the valuable metal or ore sink to the bottom of the vessel. Washing can be very perfectly performed in this way with sufficient care; and, simple as the method is, it is one which is extensively used in the washing of auriferous sands. The same thing can, however, be effected much more economically by various mechanical contrivances, such as percussion and sleeping-tables.

The water as it issues from under the stamps is made to circulate through a system of canals called a labyrinth, carrying with it the pulverized ore which is distributed at points more or less remote, dependent on the size and specific gravity of the particles. (See figure 38 which represents the most approved form of this apparatus.) In these troughs the metallic particles are deposited in constantly decreasing quantity from the end nearest the stamps to the place of exit, where the earthy particles are carried out deprived of all the ore with which they had been previously intermixed.

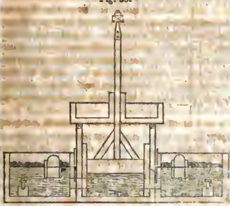
Fig. 38.



The same thing may be effected by the operation called riddling, or jigging —an operation which is performed principally on the rubbish produced in breaking the ores. This may be done by hand employing a kind of sieve or riddle, the bottom of which is covered by a plate of metal pierced with holes, which is jerked up and down, with a partially rotatory movement, in a cistern of water.

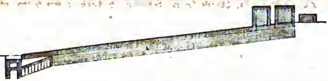
The water enters the orifices and holds the particles of ore and gangue suspended for a moment, when they arrange themselves in the order of their specific gravities, and are thus deposited in the sieve, and afterwards separated, the upper portion being removed by a spatula and rejected. Figure 39 represents a simple and effective instrument now used in the Harz for this purpose. The sieves or riddles are in this machine fixed, and the water is made to ascend and descend through them by the alternate vertical motion of a solid piston. By this arrangement the process of riddling can be performed with great ease and perfection.

Fig. 39.



The copper can be perfectly separated from the gangue in the Lake Superior ores by washing the deposites which have accumulated in the labyrinth by means of what are called *sleeping-tables*. Figure 40 represents a section of the common sleeping-table.

Fig 40.



It consists, in general, of an inclined board, at the elevated end of which a stream of water is made to run upon the mixed mass of pulverized metal and gangue. The water, as it descends the inclined surface, carries with it the particles, which tend constantly to deposite themselves in the order of their specific gravity, the heaviest nearest the upper end of the table. A workman, with a kind of rake, continually pushes the descending materials upwards, till the metallic portions have become sufficiently separated from the particles of the gangue. The former are then removed by opening a slide, through which they are allowed to fall into a suitable receptacle beneath. The same processes are repeated till a complete separation has been effected. The washed metal is then packed in strong casks and transported to the furnace, where the smelting is performed, and the copper is cast into suitable shape for the market.

CHAPTER VIII.

DRIFT OF THE LAKE SUPERIOR LAND DISTRICT.

Introductory remarks.—Drift of the valley of the St. Lawrence.—Of Lake Superior.—Division of the drifts.—Peculiarities of the coarse drifts.—Names given to the drift clay—Thickness.—Composition.—Stratification.—Extent—Origin.—Drift sand and gravel.—Composition.—Thickness.—Extent.—Stratification.—Composition.—Origin.—Influence of the waves.—Inference.—Boulders.—Their size and distribution and mineral composition.—Origin.—Transportation.—Limitation.—Their relation to the drift.

The region of the great lakes may be considered as the headquarters of the North American drift. From the mouth of the St. Lawrence to the borders of Lake Superior there is hardly a spot where the drift deposites are lost sight of. They generally form low, level plains, but sometimes rise in high bluffs and terraces, and again merely cap the promontories of the bolder cliffs.

Throughout this long line of inland country there is, however, no place where these formations are more extensive than on the southern shore of Lake Superior—more especially its southeastern coast. There, they not only constitute the only visible formations for nearly one hundred miles, but they also attain an astonishing thickness, so as to form, by themselves, ridges and cliffs which exceed in height even those of the Pictured Rocks—being in some places (for example, at the Grand Sable) not less than three hundred and sixty feet high. In consequence of this preponderance of the drift deposite, that portion of the shore of the great lake is the least attractive in a picturesque point of view—it being in the nature of the detrital deposites to soften down the contrasts, and to produce uniformity and monotony. The drift is less conspicuous along the western portion of the lake shore, although it is not wanting even among the romantic and precipitous cliffs of the Pictured Rocks and the Red Castles. The great difference which exists in the orographical and geological structure of the eastern and western portion of the southern shore has exercised a powerful influence upon the drift. Since the peninsula of Keweenaw Point, which projects so boldly into the lake, divides the whole country into distinct regions, both in a mineralogical and geological point of view, we may as well consider it also as a dividing-point for the drift—the more so, as it is now, and long will be, the general landing-place for all those who visit the shores of Lake Superior. We shall therefore start from Keweenaw Point, to examine first those drift deposites which extend to the west of it along the copper region, and afterwards those which line the coast as far as the Saut and the Straits of Mackinac.

Before we proceed to the investigation of the peculiarities and distribution of the drift masses in either of these regions, it will be proper to give a brief account of the different divisions which we have recognised. The drift of Lake Superior may be divided into four different deposites, which, in an ascending order, exhibit the following characteristics:

1st. A layer of coarse materials, composed of pebbles intermingled with loam, which we will designate as coarse drift.

2d. A layer of clay resting either on the coarse drift, or, where this wanting, on the rock. This is the drift clay of Lake Superior.

3d. A deposite of sand, gravel, and pebbles, irregularly stratified, resting upon the clay, or upon the rock itself.

4th. A considerable number of isolated boulders, scattered over the whole region, forming the uppermost portion of the drift deposites. The polished and grooved surfaces which occur in connexion with the drift constitute, likewise, a most important feature in its history. Finally, there are the drift terraces and ridges, which likewise deserve a close examination, in order to ascertain their bearing in reference to the changes of level which have taken place during and since the drift epoch.

1. *Coarse drift.*—This deposite is the least conspicuous of all. It is found only in a few places along the southern shore of Lake Superior, generally capping the high towering cliffs of sandstone, (as, for example, at the Red Castles, west of the Portage, and also at the top of the Pictured Rocks.) It is generally a mixture of loam and fragments of rock of different size—sometimes worn, but more generally angular. As a leading feature, we may state that it is almost exclusively composed of fragments of the rocks *in situ*, showing that, whatever may have been its origin, it could not have been acted upon by long-continued agencies. After a careful examination, I found but few foreign pebbles, mostly of trap, scattered through the mass, and evidently derived from the neighborhood. The whole mass is nowhere more than thirty feet thick. We ought to add further, that in many places the pebbles may be seen disappearing gradually, and the whole passing into a regular drift clay.

This deposite might, perhaps, seem hardly worth mentioning, were it not that its peculiar structure and its position remind us of a similar deposite widely diffused throughout New England, especially in the mountainous districts of Vermont, where it forms the most conspicuous feature of the drift.

2. *Drift clay, or red clay.*—This deposite has been long ago recognised as a peculiar one, distinct from the drift-gravel and sand above it, and the coarse drift beneath it. It has been described by the geologists of the Michigan State survey as the tertiary clay of Lake Superior. From its red color, which is one of its leading features, it is also called by some red clay. It is difficult to determine its average thickness, from the fact that, in many places where it is highly developed, it sinks below the waters of the lake, and in other cases, where its base is visible, its top has been partly washed away. There are, however, some places (for example, at the western portion of the Grand Sable) where it may be seen undisturbed in its natural position, its base resting on the almost horizontal strata of red sandstone, a few feet above the water, whilst its top is covered by a considerable mass of drift sand. I found the deposite in this place to be sixty feet in thickness, exhibiting lines of stratification disposed with much regularity. Its upper limit may be here seen stretching in a horizontal line for a long distance. We may well consider this locality as indicating the average thickness of the clay. However distinct the upper limit of the clay may be in general, it is also seen in many localities alternating with the sand above, or passing gradually into it—thus showing that both deposites, although of different materials, belong, nevertheless,

to the same formation, and therefore that there is no real ground to consider the clay as being a part of the tertiary formation. As far as its composition is concerned, it appears to be a mixture of loam and clay, and its color is owing to the decomposition of the red sandstone and trap from which it has been derived. Though the main mass of the clay stratum is composed of very finely comminuted substances, and oftentimes reduced to an almost impalpable powder, yet there are many pebbles interspersed through it, and even boulders of considerable size, generally rounded and smoothed. Fragments of metallic ores and native copper occur occasionally in it—the latter sometimes weighing several hundred pounds. It was by means of the fragments of copper scattered through the clay that the attention of the early travellers was first attracted to the copper mines of that region, which are now so extensively wrought.

As a whole, the great clay stratum of Lake Superior cannot be considered as being regularly stratified, though there may be seen in many places bands of different color, and differing in the size of the materials, resembling in their regularity a kind of stratification. Neither is there any striking variety to be observed between the materials, either at the base or at the top; so that the conditions under which the deposite was formed must have been uniform, and rather quiet.

As to its extent, it appears, from what we know, to be spread over an immense tract of country. Not only is it found along the whole southern coast of Lake Superior to Fond du Lac, and along the St. Louis river as far as geologists have extended their investigations, but it occurs also on the north shore, where it has been traced for a considerable distance along several rivers which empty into the lake. It was observed, however, by Mr. Whittlesey, that to the northwest of Lake Superior the drift assumes an ash-colored tint, which is owing, no doubt, to the absence of red sandstone in these regions.

If we were to consider merely the position of this clay as it appears on the southern border of Lake Superior, forming, as it does, a regular stratum, resting upon the red sandstone, and being limited to a certain height, where it is followed by the drift sand, we might well conclude that it was deposited in a circumscribed basin. This is, indeed, the impression which a traveller might receive if he were merely to coast around the lake. Such an impression would be, however, entirely erroneous; for, in ascending the highlands which rise behind those cliffs, we meet again with the same clay at an elevation of from six to eight hundred feet—as, for instance, near the Jackson location on Carp river, and in several places along the road leading to it. It also forms lofty cliffs on the river Ontonagon—as high as five hundred feet. In all these places its composition is the same as along the lake shore, being quite as comminuted, and forming the same sticky loam when wet. It ought to be observed, however, that, on the whole, it seems to be limited merely to the depressions of the soil, and never to cover the culminating points.

3. *Drift sand and gravel.*—This is the most widely diffused of all the drift deposites along the shore of Lake Superior, as well as over the whole northern part of the country. It not only covers the clay deposite in most of the localities where the latter has been observed, but also extends over many places where this does not reach. We have stated that the clay, even at its highest level, was generally limited to the depressions. The

drift sand and gravel have no such limitations. It is found on the uplands and along the slopes of the hills, as well as in the depressions. Although separated from the drift of the western prairies by the dividing ridge between the upper peninsula of Michigan and Wisconsin, yet in many places, where the ridge is not of considerable elevation, it may be seen passing directly from one slope to the other, especially on the southeastern corner of the lake—as we shall have occasion to show hereafter. It is likewise said to pass from one slope to the other at the southwestern border between the lake and the headwaters of the Mississippi. It is found on the highest summits of the Pictured Rocks—nearly two hundred feet. Its relation to the drift clay can be easily ascertained merely from the state of the roads and trails, which are generally dry and pleasant on the drift sand. No rule obtains as to the composition of the drift sand and gravel, either in reference to the size or the mineralogical character of the materials.

Layers of fine sand alternate in every possible way with layers of pebbles—sometimes by a gradual transition, at others rather abruptly. The pebbles themselves are composed of all kinds of stone—some from the immediate neighborhood, others from places more remote. They are generally rounded and smoothed, showing that they must have undergone a prolonged and violent motion, such as could have taken place only in the water. The same is the case with the boulders imbedded in the mass, of which there are many of considerable size—from five to six feet through. Many of the boulders are also covered with scratches, such as could have been produced only by a violent and steady rubbing. We would state, besides, as a further peculiarity of the drift pebbles and boulders, that they are generally clean, there being no loam or mud attached to them—a peculiarity which is in itself sufficient to distinguish the gravel drift from the loam deposites of coarse drift before described. The thickness of the drift-sand and gravel, like that of the clay, is best ascertained along the shore of the lake. There seems to be a sort of antagonism as to the relative thickness of both deposites between the eastern and western portions of the lake shore. Whilst the clay seems to assume its greatest thickness west of Keweenaw Point, the sand and gravel seem most developed to the east of that point. Its greatest thickness we found to be at Grand Sable, where the coast rises, according to Mr. Whitney's barometrical measurement, 360 feet above the lake; and since the clay stratum underneath is only sixty feet thick, it gives an amount of three hundred feet for the sand and gravel deposite. From that spot the same drift deposite may be seen extending in the form of a high cliff to the southeast, generally some miles distant from the lake shore; until it reaches it again at Point Iroquois, where it rises almost to the same height—345 feet; thence it sinks gradually towards the Saut. A further peculiarity of the drift sand and gravel deposites we would mention—their irregular and undulating surface, especially where they cover wide tracts of country: as, for instance, in the plains of Wisconsin and Illinois, which, from this feature, have been denominated *rolling prairies*, in opposition to the level prairies, which are mostly alluvial. The shores of Lake Superior are, in this respect, less striking—owing, no doubt, to the fact that the country is less level, and also in consequence of the forests which cover the ground almost everywhere. The summit of the Grand Sable, as will be noticed subsequently, is the place where this undula-

ting appearance is most striking on the lake shore. There can be no doubt that, as a whole, the drift sand and gravel is a stratified deposite, although the stratification is perhaps more imperfect than in any other sedimentary formation. The strata are generally the most distinct where the mass is composed of fine sand. They are less conspicuous in the gravel, except where it alternates with layers of sand or clay, in which case the separation into layers is sometimes very distinct. As a frequent occurrence, we would especially mention those irregular layers which have been designated under the name of *cross-stratification* by some, and of *discordant stratification* by others. There may be sometimes seen in a single section three, four, five, and even more plans of stratification, forming among themselves all sorts of angles—some horizontal, some slightly inclined, and others almost vertical. Instances of such stratification are to be seen all along the coast of Lake Superior, in the drift as well as in the alluvial sand. They are less frequent where the deposites assume a more loamy character. It is well known that this discordant stratification is not limited to the quarternary deposites, but occurs in sandstone of every age. Along Lake Superior, where the drift deposites rest immediately on the Potsdam sandstone, it is a rather impressive sight for a geologist to witness, side by side, this structure both in the oldest and most recent of the sedimentary formations, thus showing that the same laws of deposition, even in minor details, have prevailed at all times in the formation of the earth's crust. Some doubt still exists as to the cause of these singular stratifications. The attention of geologists was first directed to them in the recent deposites of the valley of Switzerland, where two rivers (the Rhone and Arve) meet. They were ascribed by M. Necker to the disturbance caused by the meeting of two currents of variable strength, contending with each other in the same bed, whence the strata resulting from this conflict were called *stratifications torrentielles*. In this way the Swiss geologists succeeded in explaining, not only the variable inclination of the strata, but also their difference of materials, when it happens that one of the currents carries coarser substances than the other. It is evident, however, that this explanation does not apply to the similar structure of the sand deposites along the sea and lake shore, where the conflict is no longer caused by rivers, but by the contending forces of waves and currents. We know, for instance, that in some shallow harbors—that of Charlestown, for example—the pilots have to make out the channel after every severe gale. This shows that the waves exert a strong influence upon the bottom, where it is shallow enough to come within their reach; and since, from the nature of the waves, we must suppose their action to be broken and unsteady, we might well expect such irregular strata to be formed wherever the waves and tides come in conflict. Along Lake Superior there are no tidal currents, as far as we know; but the currents resulting from the changes of the wind are strong enough to account for similar conflicts. If this explanation be true, we might then expect such discordant stratification wherever the water is shallow enough to allow the bottom to be stirred up by the waves. Indeed, there is every probability that all sand and sandstone formations which exhibit a similar structure have been formed in shallow water—an inference which, as far as the drift is concerned, is confirmed by other considerations, which we shall examine hereafter.

4. *Boulders.*—Of all the drift deposites, the boulders have, from all

times and in all countries, excited the greatest interest, in consequence of their size, as well as of their position. The mere view of a huge block of granite, situated, as it often happens, on the summit of a hill, whilst the rock on which it rests is of limestone or sandstone, is sufficient to excite the curiosity of every thinking man, as to the place from which this stranger may have come, and as to the mode by which its transportation was accomplished. We ought not to be astonished, therefore, that most of the theories which have been imagined to solve the problem of the drift should refer chiefly, if not exclusively, to the boulders. From looking at them in a too exclusive point of view, most geologists have misunderstood their true signification; they have overlooked the other more regular deposites with which they are connected: thus forgetting that the boulders form but a part of the drift formation, and represent but one single though striking event in a long period of the earth's history—that of the quarternary epoch. This we consider the chief cause of the insufficiency of most of the theories. Before we attempt any explanation, our object will be first to examine their peculiarities, as exemplified in the region of Lake Superior—which we deem the more important, as this region seems to have been the point of departure for many of them, scattered far and wide over the country. Boulders of every size and description occur in great numbers along the whole southern shore, and are said to be as numerous along the north shore. As a whole, they did not strike me by their dimensions. They do not by any means equal those huge masses found in Switzerland and in many parts of New England. The largest boulder which I noticed was one of hornblende, near Carp river, measuring 15 feet in length, 11 in width, and 6½ in height; another, near the Portage, measured 8½ feet in length and 5 in width. On the borders of Lake Superior, as in all other countries where drift occurs, the boulders are the most widely diffused. They are scattered over the whole country, and may be seen at all heights, where no other drift deposites reach. They are truly the vanguard of the drift formation, in height as well as space. Even the dividing ridge, where it rises the highest, does not limit their extent; for they have been found as high as one thousand feet above the lake south of the Anse, and may be from thence traced uninterruptedly along the southern slope of the ridge into the prairies of Wisconsin and Illinois. As to their mineralogical composition, there is every variety of rocks to be found, and in many instances they may be traced to their origin at no very great distance. We thus soon accustomed ourselves not to look any longer upon them as strangers, as we do where there is no analogy whatever between them and the rocks on which they rest. Among the most numerous boulders along the lake may be mentioned those of granite, trap, and hornblende rocks, which are common to both shores. Boulders of sandstone are less frequent, in spite of the great predominance of this rock along the south shore—a circumstance easily accounted for by its greater softness, which renders it the more destructible. As a general rule, it may be stated that most of the boulders scattered over the Lake Superior region have not come from far. This is of the utmost importance, since it actually enables us to trace the route which they have followed; and as to their direction, I feel no hesitation in affirming that most of the boulders within the region of Lake Superior have been transported from north to south. As instances of this southerly transportation, I shall state the

following facts. The iron region of Lake Superior is situated near Carp river, east of Keweenaw Point; and, although the ridges where the iron ore occurs are only some ten miles from the shore, yet there is not a single boulder, nor even pebble, of iron to be seen north of the ridges. This ore, of which there are innumerable fragments scattered at the foot and in the immediate vicinity of the ridges, is so conspicuous, from its banded structure, that it would undoubtedly have been noticed, if it did occur at all north of its origin. In going from the iron ridges towards the south, iron pebbles and boulders occur in abundance, and may be traced for some distance. Thus, in September last, Mr. Whitney, starting from the ridges east of the Jackson location, traced boulders of iron ore all along his route towards the Escanaba river, some twelve miles off; and they might probably be found still further south, were it not for the swampy character of the country. This southerly transportation is further confirmed by the boulders of the beach itself, which point to the north shore as their birth-place. This applies especially to the copper region west of Keweenaw Point. There trap and sandstone are the only rocks in place; and yet among the boulders scattered over the surface there are many of granite and hornblende, which have evidently their origin on the opposite shore, where we know these rocks to be very abundant. Thus it happens that, when travelling from south to north, the appearance of a new formation is always indicated by the occurrence of single boulders of it, whilst nothing of the kind takes place when travelling from north to south. This precession of the boulders is especially striking among the ridges of the iron region north of Carp river, where there is often a great variety of structure in the rocks of the different ridges. There the valleys between the different ridges contain, for the most part, boulders from the next ridge to the north. There are also instances where a ridge did not allow the fragments of the preceding ridges to pass. A striking instance of this has been observed by Mr. Hill west of the Jackson location, where the slate and iron boulders are heaped up in great quantities on the northern slope of a greenstone dike, whilst there are none on the granite slopes south of this dike, which has therefore acted as a barrier, preventing their transportation further south. This limitation prevails, however, only within the hilly portion of the Lake Superior region, between the lake shore and the dividing ridge. South of the ridge nothing of the kind seems to occur. There being no further barrier to check their course towards the south, they have travelled even to the very limit of the drift deposite; and thus it happens that boulders of the Lake Superior region are found as far south as the Ohio—that is to say, more than six hundred miles from the dividing ridge, the nearest place from which they could possibly be derived. We think, therefore, that there is satisfactory reason to consider the region of Lake Superior, and especially the rim of cliffs and hills which surrounds its basin, as the birth-place of the greatest quantity of boulders scattered over the western States of the Union between the Alleghany mountains and the Mississippi; and from this consideration, the region of Lake Superior, more than any other, deserves a close attention on the part of the geologist who attempts to solve the problem of the drift of this country. By far the greatest quantity of boulders on Lake Superior, as well as elsewhere, are situated on the surface, above all other drift deposites. This, of course, is in itself a proof that they have been deposited posteriorly to these formations. But be-

cause they are of a more recent origin, this does by no means prove that they are disconnected from the other drift deposites. We have seen that an abundance of boulders are to be found both in the drift-clay and sand of Lake Superior. The only difference between them is, that whilst those of the surface are often more or less angular, those imbedded in the clay and sand are generally more rounded, and often scratched and striated—a peculiarity which we shall afterwards attempt to explain. Now, as the boulders within the drift are of the same kind as those of the surface, and have, like them, a northern origin, (though sometimes not a great way off,) we are naturally led to the inference that they were transported by the same agencies, which must, therefore, have been at work during the deposition of the drift period. Moreover, this agency must have been as powerful at the time of the drift and clay deposites as afterwards, since we know that many of the included boulders are as massive and as heavy as those of the surface. It is evident, therefore, that no theory can be admissible which does not at the same time account satisfactorily for the transportation both of the boulders of the surface and of those of the drift-sand and clay.

5. *Grooved, scratched, and polished rocks.*—Whatever opinion we may entertain as to the cause and origin of the drift, there is a point upon which all geologists who are familiar with the subject agree, viz: that there is an unquestionable connexion between the drift-deposites and the rounded, smoothed, and grooved appearance of the rocks upon which they rest. Wherever drift occurs, it is associated with that peculiar appearance of the ledges, which is instantly recognised. The surfaces are the more perfect, as the rocks are harder and less prone to disintegration. Thus in our district they are most distinct on the trap and compact slates; less so on the granite and compact limestone; and are not expected to be found on the sedimentary limestones. In many places the striæ and furrows have disappeared in consequence of the disintegration, and there remains nothing but the rounded outline of the rocks, which, from their resemblance to fleecy clouds, have been called, in the Alps, fleecy rocks.

In many instances the polished and grooved surfaces are concealed by the drift, and are not visible until by some means the deposite is removed. This explains sufficiently why so general a phenomenon should have been for so long a time overlooked by geologists; for it is only about forty years since it was first mentioned, and only ten years since it was brought into general notice. One striking peculiarity of the rocks subjected to erratic agency consists in the fact that, whilst one side is smoothed down, the opposite side is rough and angular, as if it had been sheltered from the abrading process. These are known as the lea and strike sides. By means of this feature we are enabled to recognise the direction in which the erratic agency operated, even where there are no scratches. The lea side is invariably to the south over the whole of this district—a feature which we ought to expect, when we consider the origin of the groovings.

As a leading feature of all groovings, we may mention their straight course. Whatever the direction, they are in straight lines, whether continuous or interrupted—thus showing that they must have been formed by an agency unyielding and steadily applied. There is but one instance where curved striæ have been observed in this region, which will be noticed hereafter.

Groovings of all sizes occur. The most common form is that of paral-

lel furrows from one to two and four lines wide—sometimes extending but a foot, at others many yards. Where the rock is excessively hard they are mere striæ, which are often as distinct and sharp as though they had been graven with the point of a diamond. Hollow spots are observed, as though they had been scooped out by a round instrument; also, we observe wide bowl-shaped depressions, known as *troughs*, and which have been caused by the same agency, since they are always found parallel with the striæ. Instances of all these different forms exist on both shores of the lake and on Isle Royale.

As to the direction of the striæ in this district, it will be seen that, with the exception of a few local deviations, they are northeast and southwest—a direction which also prevails along the western shore of Michigan, and in portions of the western States. This direction forms a striking contrast with that which prevails throughout New England. There, they bear northwest and southeast. We shall hereafter attempt to explain this singular opposition in the striæ of the two regions east and west of the Alleghanies, and show their relation in determining the leading features of the continent.

6. *Terraces and ridges.*—The terraces and ridges of the great lakes have of late attracted a good deal of attention, inasmuch as they have a direct bearing upon the question of the changes of level which the surface is supposed to have undergone during the epoch of the drift. They may be seen both on the south and the north shores of Lake Superior, though they are less striking here than around the lower lakes, (Erie and Ontario.) Those of the north shore of Lake Superior have been described by Mr. Logan. They are most conspicuous at a locality called "Les Petits Ecrits," of which Mr. Eliott Cabot has given a fine sketch in his Narrative. Those of the south shore have thus far been but little noticed, probably because they occur chiefly in that portion of the lake-district which is the least visited, viz: between the Saut and Keweenaw Point. Beyond that point, there may be seen, in many places, along the shore of the copper region, high bluffs of drift; but they nowhere assume that stair-like form which is the characteristic feature of terraces. To avoid confusion, it might not be inappropriate to explain what is meant by the terms terrace, bluff, and ridge, as we shall have to allude frequently to them in the following descriptions. Drift-bluffs, or cliffs, are those accumulations of loose materials which terminate abruptly in steep slopes. The steepness of the slope depends in most cases chiefly upon the kind of materials of which the bluff is composed. Thus, bluffs of clay are steeper than bluffs of loam, and bluffs of loam steeper than bluffs of sand or gravel. The term, terrace, is applied when several such slopes are seen one above the other, so as to appear like the steps of a stair-case. Ridges differ from terraces in having a double slope, and being, therefore, real hills; whereas bluffs and terraces are merely the margins of plateaux. In a geological point of view, the terraces are by far the most important of these three forms, since they afford direct evidences of the changes of level which have occurred since the deposition of the drift. There can be no doubt that, wherever terraces of stratified materials are found above each other, the waters have once stood at so many levels. It might be, and indeed it has been, inferred from this, that when terraces occur along a shore, they ought to be found everywhere of the same size; and hence, that when their level is irregular, it is a proof that the up-

heaval was not uniform. This view, although correct in principle, is, however, apt to lead to mistakes when applied without discrimination.

Fig. 41.

Suppose diagram 41 to represent a lake. Let the water sink, or rather the land rise, at different intervals, so as to reduce successively the water-level from *a* to *b*, and then from *b*, to *c*. The beach-line, (provided there be one,) striking the shore in an uninterrupted manner, will be found everywhere at the same level; but it by no means follows that the resulting terraces will be found uniform around the whole lake. The error in this respect arises from the fact that terraces have been too often mistaken for, or confounded with, mere beaches. It should not be lost sight of that terraces and bluffs are the result of the undermining action of the waves. Their size and shape must therefore be determined by the force of this agency. If a basin of water is so situated as to have one of its shores exposed to the full force of gales, while the opposite shore is sheltered by high lands, we may easily conceive of a subsidence of the waters from a higher to a lower level, without at all altering the slope of the coast: as, for example, on the left side of the basin, *b*, in diagram 41. In the mean time, the right shore, not being protected, will be so acted upon as to occasion a succession of terraces. Again, the destructive action may be so effective in certain places as to wash off, in the course of time, even the terraces of former levels, and to leave only a single bluff, as indicated by the dotted line.

There are many places along the lake shore where the peculiar shape of the terraces and their diversity are to be ascribed to such a process.

Fig. 42.

The diagram 42 will render this still more evident. There can be no doubt that the water once stood at the foot of the upper terrace, *m*, and that, while stationary, the upper bluff was formed. Afterwards, the water-level sank, and another bluff was formed at *n*, and, still later, another at *o*. The subsidence of the water must have been intermittent—the epochs of subsidence, which are indicated by the areas between the terraces, being followed by intervals of quiet, during which the terraces were formed. But this regular succession of terraces does not extend far. It is limited to a small space in our diagram; and, as we advance towards the left, we see the intervals between the terraces growing more and more narrow, till they completely disappear—being, as it were, crowded into a single bluff B. Further on, we see the bluff itself increasing rapidly in height, and by-and-by disappearing entirely, leaving nothing but a gentle uniform slope, A. In the above instance, the circumstance that these different forms of terraces occur within a narrow space, and pass gradually into each other, excludes at once the idea of a local change of level. It must be evident to any one that they cannot but be the result of actual causes. But, should they occur at great distances,

such differences might easily lead to error. Let us suppose, for a moment, that we know the above terraces and bluffs merely from transverse sections, (such as represented in fig. 43:) would we not infer that the difference between the section, B, and section, A, resulted from the fact that B was raised higher than A, and likewise that B and A were both raised at once, whilst C was raised at three successive intervals?* Thus, not taking into account the action of the waves, and the position of the shores in reference to the predominant winds, (as exemplified in diagram 49,) we might perhaps be induced to recur to extravagant hypotheses, call in aid even the trap dikes, and other paroxysmal agencies, to account for features which are most readily explained by the mere play of meteorological agencies.

Fig. 43.

However, we do not pretend to assert that the upheavals which laid bare a great portion of the drift deposites have been uniform throughout. We know that there are, almost in every drift country, undoubted proofs of local changes of level afforded by the drift terraces; and we shall have occasion hereafter to refer to such an origin for those differences of level which are to be traced in an uninterrupted manner over vast tracts of country, especially along the sea shore. But we should be careful to call in such causes only when the phenomena cannot be otherwise explained.

Ridges are often associated with terraces, and have frequently been confounded with them. They differ from terraces in being actual hills, rising from a plain, with a slope on each side. Sometimes they extend for a long distance along the shore of the sea, or an inland lake—as, for instance, Lakes Erie and Ontario, where they are commonly used as roads, being dryer than the surrounding grounds. From their situation, as well as their position, these ridges have the greatest analogy to ancient beaches, and there can be no doubt that many of them have no other origin. In that case they are the most reliable evidence for ascertaining local changes. Beaches have almost uniformly gentle slopes, rarely exceeding 12°; but there are among the ridges some which are too high, with slopes too abrupt, to be considered as mere beaches.

Since attention was first attracted to them in Sweden, where they go by the name of *œsars*, (which mean sand hills,) I shall designate them henceforth by that name. There is every probability that they were formed as shoals, or bars, or banks, under water, rather than on the border of the coast, since we know that such ridges are forming in our day in shallow water both in the sea and large lakes. It ought to be remembered that the summit of these submarine ridges is not always even, nor their bearing necessarily horizontal; so that a slight inequality in their outlines, especially if limited to a narrow space, does no more imply a local change of level than in the case of the terraces before mentioned. Since, from the nature of things, raised beaches and œsars are expected to occur in the

*Since the washing off takes place gradually, there is every possibility that the bluff B, *b*, was once lower, and that there were terraces indicating the former levels, (*m*, *h*, *o*,) as in section C, *c*, but that they have been washed away.

same localities, it must be left to the sagacity of the observer to determine in each case to which class they belong. Instances of both have been noticed, at numerous points, along the shores of the lower lakes, but they are less frequent on the coast of Lake Superior, although not entirely wanting.

CHAPTER IX.

DRIFT—CONTINUED.

Region west of Keweenaw Point.—Thickness of the drift.—Boulders.—Furrows.—Polished rocks.—Keweenaw Point.—Absence of drift.—Isle Royale, drift boulders.—Polished rocks.—Influence of the waves.—Direction of the furrows.—Striæ occasioned by floating ice.—Iron region.—Terraces.—Height at which the drift is found.—Drift of the sandstone region.—Of the sand region.—Grand Sable.—Terraces.—Drift of the St. Mary's river.—Mackinac.—Conclusion.

Drift of the copper region west of Keweenaw Point.—The extremity of Keweenaw Point is almost entirely destitute of drift, and, for a long distance between Copper Harbor and Eagle river, the coast is lined with trap rocks, sandstones, and conglomerates, almost without any covering of loose materials, with the exception of some dunes near Eagle Harbor and Eagle river. A geologist who should limit himself to the examination merely of this portion of the coast, which is the most frequented, might well imagine that the drift deposite plays but a very subordinate part in this quarter. This impression, however, would soon vanish, if he were to proceed some distance on either side of the point. To the west of Eagle river, the coast is for many miles low, and composed of sand and gravel belonging to the alluvium of the lake. Beyond the Portage, the coast begins again to rise, forming high and picturesque cliffs of sandstone, which, from their castle-like appearance, have been designated by Messrs. Foster and Whitney as the Red Castles. The tops of these cliffs are covered with a deposite of loose materials, composed of the detritus of the red sandstone, which, from its structure and the absence of all stratification, I am inclined to refer to the coarse drift, (although it is less coarse than on the cliffs of the Pictured Rocks,) and may be seen passing by gradual transitions into the red clay. Its average thickness does not exceed twenty feet. This range of sandstone cliffs extends for some ten miles, after which it disappears again; and beyond Elm river we meet for the first time with high drift bluffs, rising boldly from the water to the height of from eighty to one hundred feet. These bluffs might easily be mistaken for sandstone-cliffs, from their color and steepness. It is only when approaching closer to them that we become satisfied as to their real nature. The succession of the strata is as follows: at the foot of the cliff is seen rising from the water a stratum of red clay, very tough and sticky, some forty feet thick; above it a layer of sand from six to eight feet thick; still higher, another stratum of clay not more than a foot thick; and covering this, a mass of sand forty feet thick, which reaches to the top. Through the whole mass of the sand, as well as of the clay, may be seen pebbles of different sizes; among them those of limestone are by no means rare—the presence of which may offer at first a difficulty, since there are nowhere in the neighborhood limestone strata, in situ, from which they might have been derived. But we shall see afterwards that there is no real difficulty in the way of explaining their origin, since that same limestone forms wide tracts of country beyond the northern shores of Lake Superior. I noticed that

these limestone pebbles were oftentimes accumulated in small layers near the top of the bluff. Among them were many fossils, which we found to belong, without exception, to the Cliff limestone. Between these bluffs and the Ontonagon river, the coast is for the most part low, and lined with shingle beaches. The drift appears only in a few places upon some low sandstone cliffs. My own observations do not thus far extend beyond the Ontonagon; but, according to Mr. Whitney, there appear again drift-bluffs similar to those just described, and of equal height, between Presqu'isle river, and Black river—also, between the latter and the Montreal river. In both places they agree in composition and structure with those first described. There are, besides, high drift-bluffs to be seen on several of the Apostle islands, and also west of these islands, where they are said to attain in some places a height from 400 to 600 feet. Though the whole mass is generally designated as clay, yet there is but little doubt that, on closer examination, there may be found also layers of sand above the clay. The thickness of the drift-strata along the lake shore, including both drift-clay, gravel, and sand, does not, however, give a correct idea of its extent further inland. In ascending the rivers which empty into the lake, we generally find the drift mass increasing considerably in thickness. Thus, for example, at the Cushman location, on the Ontonagon, the bluffs of drift may be seen rising to the height of 125 feet above the bed of the river. I noticed that there were also more pebbles and boulders interspersed through the mass, and the distinction between sand and clay seemed less striking. The whole mass may, in some places, be called a sandy loam, and seems to indicate, on the whole, a less regular and quiet action. It is seen leaning against the trap ranges on which the Minnesota location is situated, and the upper sandy layers may even be traced almost to the top of the ridge. The annexed section, fig. 44, will give an approximate idea of their disposition in the vicinity of the Ontonagon.

Fig. 44.

ds, drift-sand; *dc*, drift-clay; *S*, sandstone; *T*, trap.

The Minnesota trap ridge rises like an island from the surrounding drift-plateau and breaks off precipitously to the south. From this range, the eye embraces within its scope the great longitudinal valley bounded by the granite range on the south and the trap range on the north. The whole country is covered with drift deposites, through which the different branches of the Ontonagon and Sturgeon have cut deep ravines, forming bluffs which are still higher than those before mentioned. Pebbles of all sizes, and large boulders are seen scattered through the mass, and among them are found occasionally some of native copper. The limit of the drift to the south has not as yet been accurately ascertained. It reaches, according to Mr. Whitney, as far as the sources of the Ontonagon; and, since the dividing line between the northern and southern slope is not very prominent, we may well suppose that it spreads in an uninterrupted manner in that direction. On the whole, however, the distribution of the drift west of Keweenaw Point is not so irregular as might appear when seen from the shore. There are wide tracts of coast which are bordered

by shingle beaches, and sometimes by dunes; but these are only on the margin, and we need not go far inland to find the drift-bluffs. Even where the coast is rocky and destitute of any kind of loose materials—as, for example, at Copper Harbor—this want of drift is only an exception, applying merely to the immediate vicinity of the lake; and we have only to cross the first ridge to find it again.

Keweenaw Point, from its projecting position, is exposed to the most violent action of the gales and waves, and we may indeed easily conceive of its shore being deprived of all loose materials. Nor is it the only place where this occurs; almost all the projecting points west of it are likewise more or less barren; but in many places the drift bluffs which line the intervening bays may actually be seen rising behind the rocky promontories. There is but little doubt that, if the country were cleared of woods, there would be seen along the whole southern coast of lake Superior a line of drift-bluffs, in some places approaching close to the lake, in others receding more or less from it, but yet forming a continuous terrace, more or less elevated. As to the boulders of this part of the country, they are found scattered at all levels, not only over the whole surface of the drift plateau, but also over the different trap ridges, where the drift-clay and sand do not reach. I was shown, by Mr. Knapp, a boulder of granite five feet long and two feet high, resting on the very top of the highest knob of the Minnesota trap ridge. This boulder has preserved its angular shape, being hardly worn at all. There is every probability that boulders are likewise found on the highest elevations of the country, and continue without interruption from one slope of the dividing ridge to the other, as observed in several places further to the east. As far as their mineralogical composition is concerned, most of the boulders belong to the igneous rocks, viz: granite, gneiss, trap, and hornblende.

There is but little doubt that in this portion of the country they are for the most part, if not exclusively, derived from the northern shore of the lake, since, with the exception of some trap dikes, there are no similar rocks along the lake west of Keweenaw Point. It might be asked, have they not been derived from the dividing ridge between the upper peninsula and Wisconsin, since we know that granite occurs there? But this would suppose a transportation from south to north,—an analogy not observed elsewhere. The absence or scarcity of sandstone boulders should not surprise us, if we consider that this rock is much softer and more easily decomposed; its débris has probably been ground to powder, and formed the elements of the drift-sand and clay, while the trap and primitive rocks have furnished the boulders and pebbles.

Glacial furrows and scratches are very scanty in this part of the country. I have noticed them only in one locality, viz: on the road from Eagle river to the Cliff mines; they are on trap rock, and run north 15° east.

Drift phenomena of Isle Royale.—One of the most prominent features of Isle Royale, which cannot fail to strike any traveller coming from the south shore, is the almost total absence of drift deposites—the shore being everywhere composed of barren rocks. With the exception of some patches of coarse drift which are said to occur near the western extremity of the island, there are no other quarternary deposites to be seen, if we except some boulders which belong partly to the alluvium, and partly to the drift. I consider, as belonging to the alluvium, those boulders which are seen in several places accumulated near the water's edge, along the southern shore of the island. As an instance, I would mention those

which occur at the Siskawit Company's location, a few miles east of Rock Harbor. The boulders are here very much crowded, so as to cover almost entirely the ground for some distance; but they are limited to the immediate vicinity of the shore, not reaching higher than twenty feet. They are of moderate size, from one and a half to three feet in diameter, generally rounded and worn. In examining more closely into their composition, I found them to be for the most part trap, of the varieties known as sienitic, amygdaloid, and varioloid, with some few conglomerate and sandstone blocks—all of which occur on the island itself. This, together with their limitation to the immediate vicinity of the shore, leads me to believe that they belong, like those of the Saut, to the alluvium. Boulders are much less numerous in the interior of the island; and the opinion was even entertained by some that they were entirely wanting. In crossing the island, however, along the first tier of sections in range 37, I succeeded in detecting a granite boulder in the vicinity of Lake Desor, between the second and third ridge, at a height of 200 feet. Others have been found in similar positions near the eastern extremity of the island, by Mr. Foster, at a height nearly as great. Scanty as they may be, they afford, nevertheless, a proof that the same agency which scattered the boulders over the slopes and terraces of the south shore had also operated here; and, since there is no granite to be found on the island itself, there can hardly be doubt that they have been derived, like the granite boulders of Keweenaw Point, from the Canadian shore, where it occurs in great quantities.

Polished and scratched surfaces.—If drift deposites are scanty on Isle Royale, the phenomenon of the erratic scratches and furrows is the more apparent. The trap ledges being hard, the markings have been preserved with great distinctness; and these are rendered still more conspicuous by the denudation of the drift. I noticed particularly the polished appearance of the rocks along the eastern portion of the southern shore of the island. The best opportunity for a detailed examination of the glacial phenomena, however, is afforded at the eastern extremity of the island, where several narrow spits or promontories project into the lake. One of these is Scovill's Point; it is rather narrow, with a gentle slope on the south side, whilst the northern is very abrupt. The whole promontory is entirely barren; so that all the peculiarities of the surface, with its gentle swellings and deep, trough-like depressions, may be easily embraced in a single glance. Mr. Whitney and myself were struck with the close resemblance which these rounded and barren spots bore to some of the higher portions of the Alps: as, for instance, near the Grimsel. There is hardly a sharp angle to be seen on the whole promontory, except where it is the result of recent disintegration. The trough-like depressions are just as smooth as the knobs, and oftentimes filled with water, in which I collected several species of shells and a small fish—a species of stickel-back.

The glacial furrows, although greatly worn, were yet easily distinguishable in several places on the knobs, as well as in the troughs. I found their direction to be north 50° east. Even the northern side of the promontory is here, in spite of its vertical slope, smoothed and polished, with distinct indications of striæ, showing that the grooving agency has acted on both slopes at once. This is owing, no doubt, to the circumstance that the direction of Scovill's Point coincides precisely with that of

the striæ, whereby both sides came under the influence of the furrowing agency, whilst in other places there is but one side which has been acted upon—the other (the lea side) being sheltered. The whole northern shore of Isle Royale may be considered as one continuous lea side, in reference to the furrowing agency. Indeed, no sooner has the last promontory of the island been turned, than the rounded and polished appearance of the rocks disappears entirely. The shore, for the most part, presents nothing but high, steep, and rough walls of trap, without any indication whatever of a glacial agency, except on some of the isolated islands, whose sides are occasionally smoothed, but only on their southern slope.

After having turned the western extremity, and passed Washington Harbor, we meet again with smooth and rounded surfaces; but, from the nature of the rocks, they are less conspicuous. The shore being composed here of sandstone and conglomerate, it is not expected that they would have resisted the disintegrating influence of the atmosphere as well as the trap. Yet there are undoubted traces of glacial action even on the conglomerates, whose surfaces appear rounded and smoothed, all the pebbles being generally reduced to the same level. In some cases, there may also be seen indications of furrows on the sandstone, and even on the conglomerate. Further east, towards Siskawit bay, where the sandstone disappears and the trap again sets in, (see the map of Isle Royale in Messrs. Foster & Whitney's report,) the scratches and furrows resume their distinctness. Chippewa harbor deserves in this respect a special notice. It appears, at first, as a mere notch in the outer trap ridge, its background being limited by a wall of highly polished surfaces of a very striking appearance. There are also seen in several places distinct marks of striæ and furrows, which show the same direction as those described previously at Scovill's Point; namely, north 50° east. The most prominent, however, are on the left side, immediately at the entrance to the harbor, where there may be seen not only striæ and furrows, but also powerful excavations, some ten feet deep, and from twelve to fifteen wide, extending sometimes from fifty to one hundred feet in length. There are, besides, in the background of the harbor, fine instances of rocks, polished and worn by the mere action of the waves, which form a curious contrast with the glacial surfaces above, being undulating and scooped out in every possible manner, whilst the latter are remarkably uniform. The development of the furrows and striæ within this harbor is the more remarkable as the rocks outside show not the least indications of similar phenomena—the ledges along the coast being, on the contrary, very rough and broken. This can be accounted for only by supposing that these rocks, which are now so broken and irregular, were once just as perfectly smoothed and polished as those within the harbor; but that, being brittle, and exposed to the most violent action of the waves and gales, they have been destroyed; whilst others, being more sheltered, have retained their primitive beauty. There may also be seen in the background of Chippewa harbor an accumulation of angular boulders, which must have been stranded there by ice very recently, for they are observed heaped up around large trees, which certainly have not grown in this condition. Finally, Isle Royale affords many instances of strange local deviations in the distribution of the striæ. On the shores of Ackley bay I found on the trap ledges, striæ running due east and west, and crossing others whose direction was northeast and southwest, and others again running south 75° east. I noticed further,

that all the striæ, although very distinct, were limited to a narrow space, not exceeding two feet above the surface of the water, and not reaching more than 1½ feet below, whilst the barren ledges above, although rounded and smoothed, did not show any distinct striæ or furrows. In this case we may well be induced to ascribe their origin to the action of the ice driven by the wind on the shore, and rubbing against the rocks—sometimes in one direction, sometimes in another. See figure 45.

Fig. 45.

The question may be asked, how it happens that, being situated in the middle of the drift region, Isle Royale affords so few traces of it? I will not conceal that this is a difficulty, since, although the island is very hilly, yet the ridges nowhere exceed six hundred feet—a height at which drift sand and even drift clay are found almost everywhere on the main land. We must either suppose that there has never been any drift on the island, or else that it once existed and has been afterwards removed. The first supposition would seem the most natural, were it not for the few erratic boulders which are scattered over the ridges, and which in this case would have been the only materials that the drift agency dropped. Now, it is difficult to conceive how boulders should be isolated in this single place, whilst they are everywhere else connected. Is it not reasonable to suppose that the island has undergone a general denudation, whereby all the loose materials have been swept away, with the exception of a few boulders which remain as witnesses of the glacial agencies? At any rate, we ought to remember that this is not the only spot where such absence of drift occurs. The extremity of Keweenaw Point, as we have previously shown, is likewise barren of drift deposites; and here, at least, the supposition of a subsequent denudation seems to be beyond all doubt.

Drift deposites east of Keweenaw Point.—The shore of Lake Superior east of Keweenaw Point may be divided, as far as the drift is concerned, into three distinct regions, in each of which it assumes a peculiar character, and is connected with, or dependent upon, the orographical structure of the country. These regions are—

1st. The granite and iron region, extending from the Anse to the mouth of Chocolate river.

2d. The sandstone region, extending from Chocolate river to Grand Sable, and including the beautiful cliffs of the Pictured Rocks.

3d. The sand region, extending from Grand Sable to the Saut, where no other than quarternary formations are to be seen.

Drift of the granite and iron region.—The granite region near the Anse, and the adjoining iron region back of Carp river, are both distinguished by their hilly character, being composed of a succession of ridges running from NE. to SW., and rising to higher and higher levels towards the anticlinal axis. The projecting spits and promontories are generally destitute of drift deposites, but the intervening bays are lined either by a drift terrace or by shingle beaches of alluvial materials. That portion of the lake-shore between Granite Point and Chocolate river is particularly interesting. For a long distance, especially in the vicinity of Carp river, it is lined by a rather low terrace of drift, rising from twelve to eighteen feet above the

water and composed of sand and gravel, sometimes distinctly stratified, with specimens of cross-stratification, and sometimes containing a great many large pebbles and boulders, so as to resemble coarse drift. In some places to the west of Carp river, near Worcester, the red clay is also to be seen cropping out from the base of the terrace, where its presence is usually accompanied by numerous springs. In the rear of the first terrace, there is found another much higher, rising from fifty to one hundred and fifty feet above the level of the lake. The latter is sometimes close by the lower terrace, and sometimes it is separated from it by a space more or less remote.

Fig. 46.

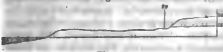


Fig. 47.

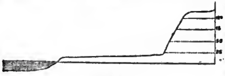


Fig. 48.

The figures 46, 47, and 48 will show the relative position of the two terraces at three different points, between Worcester and the mouth of Carp river, within the distance of a mile. As to its structure, the upper terrace seems to be composed altogether of sand finer than that of the lower terrace, and with fewer pebbles and boulders interspersed through it. If we now ascend the upper terrace, in order to explore the country inland, along one of the section lines, we find the following features. The top of the terrace is a plateau, covered generally with fine forests, without much undergrowth—the predominating trees being maples, interspersed with large hemlocks, white pines, and sometimes birches and aspens. This plateau, which would no doubt afford an excellent soil for agriculture, rises with a slight slope towards the south, till we reach the first of the rocky ridges running from NE. to SW. where the drift thins out; the summit of the ridge itself being generally destitute of it, while boulders and furrows are of frequent occurrence. This, however, is not the limit of the drift to the south, for it appears again beyond the ridge, where it forms either another plateaux, if the next ridge is at some distance, or fills up merely a valley, if the two ridges are close to each other. A succession of rocky hills and drift plateaus or valleys are thus to be traced almost to the highest elevation of the country—near the dividing ridge, each following plateau or valley being commonly at a higher level than the preceding.

In many places, the drift has been greatly washed off, and it is not unusual to find the margin of the upper terraces scooped out in deep gullies, which are oftentimes to be traced for a great distance along the smallest rivulets. These gullies are very striking in the vicinity of the mouth of Carp river, where they reminded me of similar ones in the detrital deposites of Switzerland, which go by the name of "*nants sauvages.*" They afford sometimes an excellent opportunity to investigate the nature of the drift. By far the greater portion of the drift deposite here, as well as along the shore, is composed of sand. There may be seen, however, in several localities, distinct traces of clay—as, for instance, near Teal

lake. Boulders are found scattered over the whole surface of the drift deposites, as well as on the ridges deprived of it. Some granite boulders have been observed by Mr. Hill even on the summit of Silver mountain, fourteen miles southwest of L'Anse, at the height of one thousand feet above the lake. Similar ones were noticed by Mr. Whitney and myself, inland from Carp river, at a height of 900 feet. There may also be seen, on the drift terraces of this region, indications of narrow ridges, composed of gravel and pebbles, similar to the *œsars* which occur along the coast of Sweden. One striking instance of such œsars, or ridges, may be seen on the road leading from the Jackson landing to Teal lake, a few miles from the shore. There can be but little doubt that, if the country was cleared of woods, such ridges would be noticed in many other places, for they seem to accompany the drift wherever it occurs in extensive tracts. The color of the drift (of the sand as well as of the clay) is that same reddish-yellow which prevails west of Keweenaw Point, over the whole of the copper region. There, it seems natural that it should have this color, for it rests almost everywhere on red sandstone, from which it is supposed to have been derived. Here, in the iron region, on the contrary, where the prevailing rocks are black slate, dark greenstone, and ridges of iron ore, it is evident that the drift cannot owe its origin to the decomposition of these rocks, for, in that case, it would necessarily be black, or at least very dark-colored. There is no other rock to which it can be referred; but, since sandstone occurs here in the immediate vicinity of the lake shore, the presence of red drift to the south affords additional evidence that not only the boulders, but the drift sand and clay, have been transported from north to south.

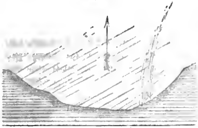
Polished and grooved surfaces of the granite and iron region.—With the exception of Isle Royale, the phenomenon of the polished and grooved surfaces is nowhere more frequent and striking than in the granite and iron regions. It is met with along the shore wherever a rocky spit projects into the lake, and in the interior wherever a ridge rises above the common level of the drift plateau, or where the drift has been removed. This frequency is owing to the fact that most of the rocks of that region, and especially those which occupy a prominent position, are very hard, and, therefore, have preserved most of the marks which have been stamped upon them by the so-called erratic agencies. Indeed the rocks are not only smoothed and polished in most places where they appear at the surface, but also distinctly grooved and scratched.

Along the coast, east of the Anse, scratches, furrows, and grooves may be seen in several localities. According to Messrs. Foster & Whitney, all the ledges of granite and hornblende between Granite Point and Dead river are distinctly smoothed and scratched. An island immediately east of Dead river is especially remarkable in this respect. The rock, which is very hard and tough hornblende, is not only grooved and furrowed over its whole extent, but there are, besides, deep, trough-like depressions, with perfectly smoothed walls, some twelve to fifteen feet long, four feet wide, and two and a half deep. Mr. Foster observed there two systems of striæ—one running north and south, and the other north 20° east and south 20° west, the latter system being the deepest and most distinct. Similar troughs were observed by Mr. Foster on Middle island, east of Granite Point. Here, too, may be seen troughs four feet wide and two feet deep, running, like the striæ, north 20° east.

The localities, however, where I found the striæ the most distinct, are the promontories and islands near Worcester, two miles west of the mouth of Carp river. The rocks are a very tough hornblende and chlorite slate, which seem well fitted to preserve even the finest lines. There may be seen, near the mouth of a rivulet, several ledges whose northern slope is covered with striæ as distinct as if they had been engraved but yesterday.

Indeed, with the exception of some localities on the black limestone in the Vinoasky valley, Vermont, and some others on the slates in the fiord of Christania, (Norway,) I do not remember having ever seen glacial striæ so distinct. The figure 49 represents a ledge with a slope of from 10° to 20° at the water's edge, where they are the most conspicuous.—There are two distinct sets of striæ: those running north 55° east are the most numerous; those running north 5° east the least. The latter are distinctly seen crossing the others, and are, therefore, more recent. Some of them are, besides, distinctly curved, as if the body which produced them had been deflected in ascending the slope—a peculiarity not yet observed elsewhere. Both sets of striæ extend here but a little way below the water—generally not deeper than one foot. This is the most eastern point where striæ occur along the shore, and, therefore, the first which comes under the observation of geologists, when coasting west. The striæ and furrows are not less conspicuous in the interior of the country, and may be traced at all heights, and on all kind of rocks, in the neighborhood. I found them 500 feet high on the summit of the quartz ridge in the immediate vicinity of Carp river; 750 feet on the iron ridge south of Teal lake; and as high as 1,000 feet on a greenstone ridge near the water-shed.

Fig. 49.



Among the most remarkable are the striæ on the quartz, if we consider the very great hardness of the rock; and, indeed, with the exception of some quartz veins among the granite of the Alps, I know of no other localities where the striæ may be traced for any considerable extent on this rock. The surfaces of these quartz hills are in some places so smooth as to glitter like mirrors in the sun, and may thus be seen from far. The rock is too hard to allow deep furrows; the groovings are, therefore, merely very fine striæ, but of such distinctness that one would think them to have been engraved by the point of a diamond. Their direction on the nearest quartz ridge is, according to Mr. Whitney, north 20° east; but on the second ridge (at a height of 531 feet) I found their direction to vary between 25° and 30°. No geologist can look at striæ on such a rock without being convinced that the action of the water is utterly insufficient to produce such effects. The same inference may be drawn from the polish and striæ at the top and along the sides of a very remarkable knob of conglomerate quartz in township 27, range 25. Notwithstanding the variable hardness of the pebbles of which this conglomerate is composed, the striæ on it may be traced in an uninterrupted manner sometimes for a distance of several feet, passing successively over a pebble of granite, of hornblende, of slate, of greenstone, and of iron ore. Their average direction

is north, varying from 50° to 60° east. Striæ are also to be seen on the iron ridges, sometimes on almost pure iron ore—as, for instance, on a ridge along the road leading to the Jackson location, two miles south of Teal lake. Their direction, as far as we could ascertain without a compass, (which is of course unreliable here,) is north 50° or 60° east.

Finally, I would make mention of a green magnesian rock, with vertical walls, to the east, along the road leading from the Jackson landing to Teal lake. The walls, although almost semi-cylindrical, are covered with striæ, which may be traced along the surface, like hoops around a gigantic cask.

Fig. 50.

This is an important instance, since it goes to show that the striæ could not possibly have been made by an iceberg, or any other body floating in the water, but that the agency must have been such as to conform to the direction of the rocky wall.

As a whole, the direction of the striæ in the several localities where they have been observed within the granite and iron region are as follows:

	Main direction.	Secondary direction.
On Middle island, east of Granite Point	N. 20° E.	
On an island, east of Dead river	N. 20° E.	N.—S.
At Worcester	N. 55° E.	N. 5° E.
On the first quartz ridge, one mile from the mouth of Carp river	N. 20° E.	
On the quartzose conglomerate knob, township 47, range 25	N. 50° 60° E.	
On the Iron ridge south of Teal lake	N. 55° E.	
At the Jackson forge	N. 65° E.	

Although there is considerable variation in the direction of the striæ and furrows, yet we cannot fail to notice that they all run east of north, whilst we have thus far seen none running west of north. The direction northeast and southwest seems to be the prevailing one, especially on the ridges in the interior. It is also, as we have seen, the prevailing one on Isle Royale. Along the shore the direction seems somewhat more northerly, (N. 20° 25° east,) corresponding to that observed on Keweenaw Point. Finally, where two sets are seen crossing each other—as, for instance at Middle island—the northerly direction has thus far proved to be the more recent one.

Drift of the sandstone region east of Keweenaw Point.—The sandstone region east of Keweenaw Point extends from the mouth of Chocolate river to Grand Sable—more than sixty miles—including the high range of the Pictured Rocks.

From Chocolate river to Traine river, for a distance of twenty-five miles, the shore is bordered with low, alluvial deposites, with pebbly beaches, and hillocks of blown sand. Three small rivers empty into the lake along this coast, nearly at equal distances from each other, viz: Fish river, Laughing-Fish river, (Riviere du poisson qui rit,) and Pebble river, (Riviere aux galets.) The rock in place is exposed to view only on a few promontories; but the land rises considerably in the rear, and there is every

probability that, in following up any of these rivers, the drift may be encountered at no great distance.

After having passed Pebble river, the sandstone intersects the shore, forming rather low bluffs, covered with a deposite of drift-loam from five to ten feet thick. Then the ground rises suddenly to the height of nearly one hundred feet. We noticed that its slope was covered with a strange mixture of detrital materials, composed of huge angular fragments of sandstone and of rounded granite boulders, giving it the appearance of a vast accumulation of very coarse drift. Having landed there, I soon noticed regular sandstone strata beneath the detrital covering, and satisfied myself that this strange mixture was owing to the disintegration of a soft layer of sandstone near the top of the cliff, which, in scaling off, had caused the layer above to crumble down, together with the deposite of drift which caps the summit. The drift at the top of the cliff attains here a thickness of twenty-five feet, and is remarkable for the quantity of large boulders which it contains. Beyond this point, the sandstone disappears again from the shore, and the coast is lined for some distance with a drift terrace from fifteen to eighteen feet in height, in every respect similar to that which we have described near Carp river.

Traine* bay, which follows next, is lined with shingle beaches and dunes. Having ascended Traine river, which empties into this bay, we reached the drift terrace, after having threaded the innumerable windings of its channel, through a low and swampy plain, at a distance of only a few miles from the coast.

The terrace averages from twelve to fifteen feet in height, and is composed of a reddish sand, with many pebbles scattered through it The same drift-sand, although less loamy, prevails also around Traine lake, some five or six miles inland, above the mouth of the river.

Beyond Traine bay, begins the range of the Pictured Rocks, the most romantic portion of the southern shore, extending some ten miles from Grand island eastward. Though highly attractive on account of its scenery, this region is less important in reference to the drift, which plays here but a very subordinate part. However, there is seen at the top of the high, towering bluffs a stratum of loose materials from ten to thirty feet in thickness, composed of pebbles and boulders, intermixed with loam and sand. I consider this deposite, like that formerly described as occurring on the summit of the Red Castles, as belonging to the coarse drift. The most striking feature is derived from its structure, being composed almost exclusively of fragments detached from the sandstone ledges beneath.

Although imbedded in a kind of loam, the fragments are but little worn, whereby they differ essentially from the boulders and pebbles imbedded in the drift clay. After a careful examination of the materials in several localities, I found but few foreign pebbles among them, chiefly fragments of trap.

There are some few places, however, where a stratum of drift-sand may be seen covering the coarse drift. Such an instance occurs at the top of the Grand Portal. It was at first doubtful whether this stratum, which is very homogeneous, had not, perhaps, originated from blown sand from below; but, on closer examination, I found that it contained a certain number of rounded pebbles, which rendered such a supposition inadmissible.

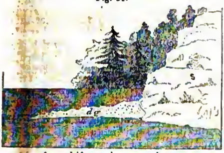
* *Traine* is an antiquated French word, still in use among the Canadian French, for *traineau*, a sleigh. We heard from one of our voyageurs that there had been, for a long time, an old sleigh near the mouth of the river: hence probably its name.

The average thickness of this sand stratum, at the top of the Pictured Rocks, does not exceed ten feet, although it is in some places as thick as thirty feet.

Along the whole range of the Pictured Rocks, there are but two localities where the high wall is interrupted so as to afford a safe landing-place, viz: at Miner's river and at Chapel river, near the Grand Portal. The first of these two rivers empties into the lake near a most picturesque promontory, which Mr. Whitney calls Miner's Castle. To the east of this promontory extends, for the distance of nearly a mile, an alluvial plain, covered with ancient beaches. The drift appears at the surface, but there is little doubt that it may be found along the banks of the river. A considerable layer of drift occurs on the top of Miner's Castle, composed of a whitish clay filled with pebbles and fragments of the underlying rock.

At Chapel river, the high cliff is interrupted for the space of half a mile, where the coast is lined by a drift terrace some thirty feet in height, being the border of a plateau stretching for several miles inland, and covered with pine openings. There, I had a fine opportunity of examining the relation of the drift to the surrounding cliffs. At the western corner of the opening, the different sandstone strata are abruptly broken, sometimes stair-like and sometimes with bold projections. There, I saw drift not only covering the lower steps of this gigantic stair-case, but filling, likewise, the space between the projections, as shown by the following diagram. It is obvious from this fact that the cliffs of the Pictured Rocks had already, at the time of the deposition of the drift, the same irregular and broken outlines which render them so conspicuous now.

Fig. 51.



d. g. drift-gravel. *s.* sandstone.

It is well known that the top of the Pictured Rocks is not a mountain nor a ridge, but merely the margin of a sandstone plateau, which rises here abruptly to the height of nearly 200 feet. Having ascended the cliff, near Miner's river, we found the plateau almost level; yet, most of the rivulets, instead of emptying into the lake, run southward, so that the water-shed is here near the very margin of the cliff. Although the surface of the plateau is thickly wooded and partly covered with swamps even at its highest levels, yet wherever the soil is removed, we found the underlying rock to consist of sandstone, and it soon became evident to me that the drift plays but a very subordinate part, being confined merely to some scattered boulders and pebbles.

No glacial furrows and groovings have been observed within this district, which is not to be wondered at, if we consider the nature of the prevailing rock, being soft, and easily decomposable sandstone.

DRIFT OF THE SAND REGION.

This region, the most important as far as the drift is concerned, begins where the cliffs of the Pictured Rocks, after having sunk within a few feet

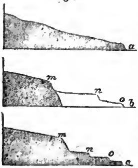
of the water's edge, are suddenly replaced by a high ridge of lose materials, called the Grand Sable. From thence, along the whole length of the coast, to the Saut, a distance of nearly one hundred miles, there is no other formation than drift and alluvial deposites to be seen. The latter is the most prominent; but wherever the drift comes close to the shore, it is generally in the form of high terraces, with abrupt slopes, exceeding even the highest points of the Pictured Rocks—e. g., at Grand Sable and Point Iroquois.

The Grand Sable, from its peculiar and very striking appearance, deserves a more accurate description. The traveller, in coasting along the beautiful and thickly-wooded cliffs of the Pictured Rocks towards the Saut, after having seen the cliffs of sandstone gradually descend within a few feet of the water, is suddenly struck by the appearance of a high, naked wall rising immediately from the lake, and extending for many miles in an easterly direction. (See diagram 52.)

The contrast afforded by such a barren tract in the midst of the dense forests which extend all around is in itself most remarkable—the more so as it seems, at first, to be nothing but a gigantic heap of loose sand. Indeed, since Schoolcraft first described it as a dune, it has generally been thus represented by all subsequent writers. Besides, the fact that the cliffs of the Pictured Rocks to the west of Grand Sable are of a very loose and easily-decomposable sandstone, seemed to justify the idea that this high sand-ridge might be nothing but the detritus of decomposed sandstone strata, heaped up by the power of the northwest winds, which are known to be the prevalent ones on the lake. But yet, it seemed difficult to conceive that sand should accumulate to the height of 366 feet in that single spot, whilst at other places along the shore—for example, at White Fish Point—the dunes should not reach higher than from forty to fifty feet, though the winds are equally violent. Even along the seacoast, under the influence of the oceanic gales, the dunes do not attain so great a height; for those of Provincetown, on Cape Cod, which are certainly the most remarkable on this side of the Atlantic, do not exceed eighty feet.

Having landed on the promontory at the entrance of the bay, bordered by the high, barren ridge, in order to investigate the subject more closely, we soon discovered along the partially naked cliffs a distincly marked line, (a,) which was found to be the upper limit of the red clay. (See figure 52.)

Fig 52.



D. C.—Drift clay.
D. S.—Drift sand.

Above this clay was a mass of sand with indications of horizontal stratification, which, from its appearance as well as from its position, we recognised as the drift sand.

Taking this fact as a standard, we followed the cliff towards the east for some distance, and were able to recognise all along, the same relative position between the clay and sand. Thus, we ascertained that the dune-like appearance is owing merely to an external covering of loose sand, and that the main body of the ridge is made up of drift sand and clay, the latter appearing at the surface in some spots, which are indicated by occasional clumps of dwarfish trees. The Messrs. Whitney, having ascended to the top of the sand ridge in order to measure its

height, found our suspicion entirely confirmed, for they discovered at the very top, layers and masses of coarse pebbles resting upon the sand, and scattered through it.

These, of course, could not have been blown up from below. They found the surface of the ridge very irregular, with deep hollows, and presenting to the south a steep slope, similar to that facing the lake, and equally barren, but less high, being only fifty or sixty feet. Beyond, the surface of the plateau was again covered with trees. The question will be asked, therefore, how it happened that a mere ridge should be so barren, whilst along the shore the drift is covered with dense forests. The cause of this peculiar feature lies, no doubt, in the fact that the drift is here very loose and destitute of any loamy substance. If by any cause (windfalls or heavy rains) the vegetation be carried away, the sand remains exposed to the wind, and, being very fine and dry, it is gradually blown off and scattered over the surrounding country. Of this we have direct proof in the isolated hillocks covered with trees which indicate the former level of the plateau. These will probably after a while also yield to the power of the elements. Meanwhile, they give us the measure of the amount of the materials which have been already taken off from the summit and scattered over the surrounding country.

There may be seen in many places along the slopes of the sand ridge of Grand Sable parallel lines—sometimes horizontal, sometimes bent and undulated—which might at first be mistaken for lines of stratification. I am rather inclined, however, to consider them as indications of successive fallings of the sand coatings, which would take place when the slope becomes too great, as it happens with the snow on the steep slopes of the Alps. Another similarity between these sand slopes and the snow-covered walls of the high mountains, may be found in a peculiar fluted appearance resulting from the falling off of small particles in the same direction.

Finally, there may be seen at the top of the long ridge of Grand Sable, towards the eastern extremity, some irregular hillocks, more or less angular, which have all the appearance of genuine dunes, and which in all probability were heaped up in the same way. Between them and the true dunes there is only this difference, that the sand is derived from a higher spot, instead of a lower one.

Between the eastern extremity of Grand Sable and Two-hearted river, a distance of nearly thirty miles, the lake shore offers but little of interest, being composed entirely of alluvium, covered and capped in many places with dunes. The drift terrace appears nowhere on the coast, but is generally seen lining the horizon at some distance. At Two hearted river it approaches the shore within less than a mile, and is composed of the same red sand as further west. It rises here to the height of fifty feet.

At a distance of six miles east of Two-hearted river, another smaller river empties into the lake, known as Carp river, but, to avoid confusion, it has been designated on the map as Terrace river.

There, the drift again approaches the shore, forming a succession of terraces, which deserve a special attention, as being the most striking instance of this peculiar structure along the south shore of Lake Superior.

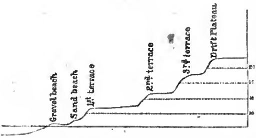
There are, in some places, not less than six successive terraces, which, when close to each other and combined with the beaches, appear from the lake, like a gigantic stair-case leading to the drift plateau above, rising to the average height of nearly one hundred feet—a height corresponding

to that of the upper terrace of Carp river, as described above. Mr. Whitney, who measured the relative height and position of the terraces at a place two miles east of Two-hearted river, found the following succession:

	Height.
1. Gravel beach - - - - - -	5 feet.
2. Sand beach - - - - - -	12 "
3. First drift terrace - - - - -	29 "
4. Second drift terrace - - - -	46 "
5. Third drift terrace - - - - -	75 "
6. Summit of plateau - - - - -	94 "

The position of these different terraces, as well as their relation to each other, is represented in natural proportions in the diagram fig. 53.

Fig. 35.



It will be seen that, although the distances of the four upper terraces are variable, yet their slopes are rather uniform, being on an average 30°. The slopes of the two lower terraces are, on the contrary, much less, being from 10° to 12°—a circumstance intimately connected with their origin, for they are true beaches, having been actually *built up* by the action of the waves, whilst the upper ones indicate merely the denudating action which the drift underwent—the crumbling down of the sand under the influence of the waves, when the relative level of the lake and the shore was different from what it is at present.

The several terraces thus indicate, in all probability, as many periods of subsidence. Since the steepness of a slope depends chiefly upon the nature of the materials of which it is composed, it is to be expected that like materials will present a uniformity of slope; and thus it is that the slopes of all drift terraces are so constant. This constancy furnishes in itself a striking feature of the drift terraces, by which they are easily distinguished from mere beaches.

The surface of the terraces is not always level, but undulating, and covered with ridges, as it appears from the above section. Some of these ridges—for instance, that marked *o*, in the section—are probably ancient beaches.

Indeed it is easily conceivable that, if the coast of Lake Superior were to be raised some thirty or forty feet, the two alluvial terraces, which are now close to the water, would appear in the same manner upon the new terrace, whose slope would soon be the same as that of the upper ones.

Beyond Terrace river, the drift terraces recede suddenly from the shore, and are not again seen until after having turned White-Fish Point, we reach the bottom of Tequamenen bay. Thus, the whole country in the vicinity of White-Fish Point, comprising an area of nearly two hundred square miles, and including the lower portion of Tequamenen river, is nothing but a low, alluvial and marshy plain, which owes its origin to the action of the prevailing winds and currents.

Point Iroquois is, as we have stated before, a high ridge rising immediately from the water, and, in all probability, composed exclusively of drift materials. From thence, the drift terrace is seen skirting the shore along Waiska's bay as far as the Saut, where the Potsdam sandstone appears again below the drift deposites. There are, besides, in Tequamenen bay, several islands, which seem to be composed entirely of drift, containing a great many rounded boulders and pebbles, from which have been derived the stones used in the construction of the light-house at White-Fish Point. Iroquois island, opposite the point of the same name, is made up of like materials. Here I noticed that a great proportion of the boulders and pebbles were of sandstone, which leads me to believe that this rock must be in place somewhere in the neighborhood.

Drift deposites along the St. Mary's river.—The same drift terrace which we have described as skirting the southern shore of Lake Superior is here seen. At the Saut, it attains a height of nearly 100 feet, and is separated from the river by a level and swampy plain, destitute of any detrital materials except boulders, which repose on the sandstone. The terrace can be traced eastward—sometimes in the form of a regular plateau, and sometimes in that of irregular ridges—until lost sight of beyond the Neebish rapids. A corresponding one is observed on the British side, but of more limited extent, separated from the river by a similar plain, and bounded on the other hand by a chain of elevated hills.

The phenomena of the glacial furrows are very marked in many places along the St. Mary's river. In the vicinity of the Neebish, the rocks are smooth and rounded, as though polished artificially, and glitter in the sun like the finest polished surfaces of the Alps. The general direction of the grooves is N. and S., and the rocks exhibit a lea and strike side.

Along the Straits of Mackinac the drift is rarely seen; but on the higher points of land, limited patches are observed. Its position on the island of Mackinac is particularly interesting, where it is restricted to the summit, forming a stratum 100 feet thick.

Accustomed to observe the drift occupying only the lowest depressions, its position here at once arrests the attention. The following diagram illustrates its relation to the older rocks and to the alluvial terraces:

Fig. 54.

a. Alluvial. d. Drift. l. Limestone.

Like the drift at the Saut, it consists of loamy sand, without any distinct stratification, intermixed in places with considerable clay.

Coming from the lower lakes for the first time, where the clays are buff and blue, the geologist is in doubt as to the real position of these patches; but, after having visited Lake Superior and examined the drift accumulations, he has no doubt whatever. To Mr. Whittlesey belongs the credit of having first suggested the identity of the two deposites. As this clay is traced southerly along the shores of Lake Michigan, it is found gradually passing into the blue clay of the west. Thus, the island of Mackinac, with its summits covered with drift, constitutes a most important link in the chain of evidence to identify remote deposites, as belonging to a common

epoch. We are thus enabled to connect the drift deposites of Lake Superior with those which form the plateaux of Wisconsin and Illinois.

The boulders on the island, which are numerous, rest upon, or are imbedded in, the drift. From their external characters, it is inferred that they were derived from the northern shore of Lake Superior.

We can account for the peculiar position of the drift here, and its absence on Round island and Bois Blanc, only by supposing that it has been removed by denudation.

The topographical engineers inform me that it is to be found on the high ground in the vicinity of Point St. Ignace. Hence, we infer that at one time it was spread over the entire area, and that a general denudation has taken place to the height of nearly 200 feet.

This denudating process, however, did not limit itself to the removal of the drift materials. The island affords evident proofs that the more ancient rocks have not escaped. That curious and picturesque rock known as the Sugar Loaf, which rises like a pyramid, to the height of ninety feet, from the surrounding plain, remains a monument of the ancient water-level.

There can be no doubt that this denudation is to be ascribed to powerful currents of water, at a time when the general level of the country was different from what we now behold it. That these currents were long-continued, is proved by the many alluvial terraces which encompass the island, of which we shall treat hereafter. No glacial furrows have been observed on the island, or along the straits; but there is little doubt that such markings might be traced on the rocks, if the superficial materials were removed. The soft porous limestone which here prevails, is ill adapted to retain such markings for any great length of time, when exposed to the influence of atmospheric agencies.

CONCLUSION.

It is not intended here to give a general theory of the causes and origin of the drift, since it would oblige us to allude to many phenomena foreign to the district under consideration, and to discuss the many systems which have been proposed by various authors to solve this great problem. I shall, therefore, limit myself, for the time, to a brief sketch of the principal periods which may be recognised among the drift deposites of Lake Superior. A mere glance at the relative position and structure of the drift deposites, as described in the foregoing pages, will suffice to prove that the phenomena neither indicate a paroxysmal agency, nor the operation of a single cause, however long continued. They disclose a long series of events, which have resulted from causes highly diversified, and as yet but imperfectly known. We recognise the following periods in the history of the drift of Lake Superior:

1. The period of the grooving and polishing of the rocks must be considered as the dawning of the drift epoch. At the close of the tertiary era, (which has left traces of its presence over many of the States bordering on the Atlantic, as far north as the island of Martha's Vineyard, in Massachusetts,) the whole northern portion of the continent was subjected to the operation of a general and most powerful agency, of which there is no precedent in the history of former geological ages. There may

be found in every sedimentary formation, deposites similar in their composition to those of the drift, but the rocks on which they rest are nowhere characterized by those peculiar markings which we have described as glacial furrows and striæ. In the region of Lake Superior, they are found at all levels—over plains, and on the slopes of the hills and mountains. Even the dividing ridge between the upper peninsula and Wisconsin exhibits traces of their action. It is proved that here, as well as in Europe, their main direction has been from north to south—being, however, sometimes deflected either to the east or to the west. These deflections are, no doubt, dependent upon the leading physical features of the country. Along the south shore of Lake Superior we have found them running mostly from northeast to northwest, a direction parallel with that of the principal ridges—as, for instance, those of Isle Royale and Keweenaw Point. These coincidences would be still further strengthened, if it could be ascertained by a series of soundings across the lake, that the main troughs ran in the same direction. We know, in the actual operations of nature, of no agent capable of producing such a gigantic result as the shaving and smoothing of a whole continent. To those who are familiar with the effects produced by glaciers upon the walls and bottoms of the valleys through which they move, it cannot be denied that they exhibit the closest analogy to the phenomena which we have been describing. The appearance of the rocks, as well as the form and size of the striæ, is the same; yet it must be remembered that, in our days, glaciers occur chiefly in the valleys of the highest mountain chains. It is, therefore, difficult to conceive how they could exist and move in a wide and level country, like the northern parts of the United States and Canada. In order to avoid this difficulty, it has been assumed that the whole northern hemisphere, as far as erratic phenomena reach, was once covered with a general cap of ice, similar to that of the circum polar region, which, in its southerly progression, is supposed to have at once smoothed the rocks and transported the boulders from north to south.* A careful examination of the position of the boulders, which I have found, both in this country and northern Europe resting mostly on stratified deposites of sand or clay, has convinced me that the above assumption is no longer admissible, so far as it relates to the transportation of the boulders. The remaining question relates to the grooving and polishing of the surface rocks. However inclined I may be, from personal observation of the glacial phenomena both in the Alps and Scandinavia, to refer the groovings to this agency, according to M. de Charpentier's theory, (which is also advocated by M. Agassiz,) I shall refrain from entering into any discussion of the subject, for the reason that the laws which regulate the motion of the polar ice are as yet too little known to be made the basis of geological speculation in a report like this, the object of which is to state facts and give particular information. Whatever may have been the cause of the groovings, it must be admitted that an agency which was capable of shaving off and wearing down such an extent of surface must also have been able to remove the detritus and to transport it from one place to another. I am inclined, therefore, to ascribe to this agency, and to consider as contemporaneous with it, that portion of drift materials which

*As to the difficulty arising from the climate, I would remark that it has been most ingeniously shown, in a recent paper by M. Lecog, that if polar glaciers have ever existed in these latitudes, it was possible only with a higher temperature.

I have described as coarse drift, and which, wherever it exists, is regularly found at the base of the stratified deposites, having been left undisturbed by the waters of the subsequent period.

2. We have shown that almost everywhere along the southern shore of Lake Superior there is a stratum of red clay resting on the coarse drift, or, where this is removed, on the polished rocks. From its thickness and the comminuted state of the materials, we infer that during its deposition a long interval of time elapsed, characterized by no violent agitations. With this stratum begins the second era of the drift. If it should be proved that the continent stood, during the preceding period, at a higher level than now, as some phenomena seem to indicate, this circumstance would afford additional evidence in favor of the separation of the two periods, since it would imply a subsidence of the continent, at the beginning of the deposition of the clay, by which the shores of the lake were brought within the reach of the waters to the height of the surface of the red clay. Admitting this, we must suppose that the former detritus was to a great extent swept away, and deposited in a more quiet manner.

As to the boulders distributed through it, we may suppose that they were transported by floating ice, in the same manner as their transport is at this day effected every spring from the borders of the northern lakes and rivers, and dispersed over the adjacent swamps and low lands.

The question recurs as to the nature of the waters—whether they were salt or fresh. Considering the vast area over which the clay is spread—it being traceable not only along Lake Superior, but also along the St. Mary's river to Mackinac, and thence along Lake Michigan to the prairies of Illinois—it would seem to have constituted a part of the ancient bed of the ocean. It should, however, be remembered that we have, in former geological epochs, fresh-water formations extending over considerable areas, particularly during tertiary and carboniferous eras.

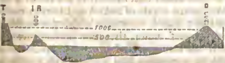
At any rate, the question must remain doubtful, as long as we have no evidence of fossil remains. Thus far, I know of no type of animal or vegetable life having ever been found in the clay of Lake Superior.

3. We have found everywhere resting upon the clay of Lake Superior a stratum of gravel and sand, which, notwithstanding its irregular structure, is a real stratified deposite and must therefore be supposed to have been formed in water. Occurring at still higher levels than the drift clay, and attaining sometimes a thickness of several hundred feet, we must suppose that at the time of its deposition the country had subsided to a still lower level. From the diversity of its stratification we infer that this period was characterized by intervals of agitation and repose. According to Mr. H. D. Rogers's ingenious theory, this feature should be ascribed to the temporary operation of earthquake waves, such as are known to occur occasionally in our days, especially in the Pacific. Such waves might well have disturbed the bottom of the ocean, carrying before them an immense freight of detrital materials, which were heaped up in irregular masses and hills, resembling the drift accumulations. If we suppose similar disturbances to have been of frequent occurrence, they might well account for the absence of all organic remains at that epoch.

I consider, as belonging to the close of this period, the transportation of those huge boulders which are scattered in such vast profusion over the surface of the gravel deposites, and which we have detected on the very summits of the anticlinal axis, where no other drift deposites occur. It might

thus appear, at first that this epoch had been characterized by more violent agitations than the preceding one. We should be careful, however, not to judge of the power and violence of an agency merely from the size of the materials transported; for, if the boulders had been conveyed by powerful currents, we should not only find them of diminished size in their progress southward, but also rounded and smoothed like the smaller pebbles. On the contrary, we know that they are just as massive at the very limits of the drift in Ohio, as near their birth-place; besides, many of them along the anticlinal axis are perched, as it were, on the very top of narrow hills and knobs, where it is hardly admissible that they should ever have been left by a violent agency. Finally, many of them, in spite of contradictory assertions, have rather sharp angles, as if they had been subjected to slight attrition. I am therefore inclined to suppose that the surface boulders, like many of those buried in the drift-clay and sand, have been transported by floating ice, (not icebergs.) By this hypothesis, their position on the summit of the hills offers no longer any difficulty; for it is natural to suppose that they should have been stranded upon those points, which at the time were shoals. The changes of level which the region of Lake Superior has undergone during the drift epoch are represented in the following diagram. Assuming that, during the period of the groovings, the waters stood nearly at the same level as now, the land must have sunk during the second period to the depth of five hundred feet, and again the same amount during the third period, when they reached those summits, which are now one thousand feet above the lake.

Fig. 55.



T., Thunder Cape. I. R., Isle Royale.
D., Dividing-ridge.

The boulders of Lake Superior, like those of all other parts of the country, point to the north as the source of their origin; yet there is this difference, that they are not generally derived from far. Those in the immediate vicinity of the south shore have in the main been derived from the north shore, but as a whole they are not very numerous; and I have Mr. Foster's authority for stating that very few have passed beyond the dividing ridge. The boulders and pebbles of the opposite slope of the axis, although more numerous than on the northern slope, are all derived from the dividing ridge itself. The same is true to a great extent of those scattered over the plains and prairies of Wisconsin and Illinois. This ridge, abounding in eruptive and metamorphic rocks, is therefore to be considered henceforth as the true birth-place of the boulders scattered over the western States, and we need no longer recur to high northern latitudes to ascertain their origin. The drift epoch may be considered as closed with the transportation of the boulders. The waters, after having thus reached their highest level—during which the transport of the boulders and pebbles was accomplished—again subsided. With this subsidence commences the era of the alluvium. We have no reason, however, to suppose that the subsidence was sudden. Everything leads us to believe, on the contrary, that it was gradual, and that the same agencies continued to operate to a certain degree. Thus we may infer that beaches were formed, sand bars built up, and boulders transported, in the same manner as before, although at lower levels. Meanwhile, the former and higher

beaches receded more and more from the shores; the bars, shoals, and sub-marine banks appeared as ridges or oesars above the plains recently laid dry, whilst new ones were forming at lower levels; and whenever the water, in its receding movement, stood for a sufficient time at the same level to allow the new shore to be acted upon and undermined by the waves, these bluffs and terraces were formed, as shown before. Now, since terraces and ridges occur frequently along the great lakes, they may be considered as a conclusive proof that the subsidence was really gradual. In this respect, terraces and ridges, although composed of drift materials, belong properly to the alluvial period, as well as the denudations along the channels through which the waters are supposed to have been discharged. I shall therefore examine them with more detail in my report upon the alluvium. Thus far, we are not aware of any striking geological event—such as the elevation of a mountain chain—having taken place between the two epochs of the drift and alluvium. It might therefore be asked if there is sufficient reason to separate them. There are, indeed, some geologists who question the propriety of such distinction. My chief motive in adopting it is derived from all of the drift phenomena, rather than from any single event.

The drift is the last phasis of any importance through which the earth passed before it became fitted for the habitation of man. Were it not for these deposites, a great portion of this continent, including the district embraced in this report, would have been a waste of naked and barren rocks, covered partially with heaps of dry sand or rough detrital materials. Through the long-continued agency of water, these materials have not only been reduced and dispersed, but also mingled in such proportions as to afford a most appropriate soil for vegetable and animal life. When, afterwards, the rise of the continent caused the waters to recede within their present limits, they left behind them those wide, drift-covered plains, destined to become, in the lapse of time, the seat of an industrious, intelligent, and prosperous nation. We think ourselves justified in considering the period, when the waters, after having done their work, began to recede, as the beginning of that new and grand era which has been properly called the era of MAN, and of which the alluvial period is the introduction.

GLOSSARY OF MINING AND METALLURGIC TERMS.

For convenient reference, we have prepared the annexed glossary of the technical and provincial terms relating the science of mining and metallurgy, which includes most of those in use in this country and in books treating of these subjects. The fact that a great number of Cornish and German miners are employed in our mines readily accounts for the introduction of foreign, provincial and technical words, many of which are already in familiar use in the Lake Superior copper region; others are used in foreign works treating of mining and metallurgy, and have been adopted in English books, when we have no word expressing exactly the same idea.

In the glossary, the letter *C*, affixed to a word signifies that it is of Cornish origin; *F*, follows a term adopted from the French, and *G*, from the German language.

GLOSSARY.

Abstrich.—(*G.*)—Impure litharge obtained in the operation of separating silver from lead ores.

Abzug.—(*G.*)—The first, very impure litharge which is formed in the operation of cupelling argentiferous lead-ores.

Adit—adit-level.—A horizontal excavation or gallery through which the mine is drained. The adit-level is usually commenced from the bottom of the lowest neighboring valley, and extended through the workings of the mine.

Adventurers.—Shareholders, or those interested in a joint mining enterprise.

Air-machine.—Apparatus for ventilating a mine by withdrawing the foul air from it, or by forcing in pure air from the surface.

Arch.—A piece of ground left unworked near a shaft.

Attle.—Rubbish; rock containing too little ore to be worth working.

Average standard.—(*C.*)—The price per ton of the fine copper in the ore, after deducting the charge for smelting, which amounts, at Swansea, to £2 5s. per ton of ore.

Back.—The back of a lode is that part of it which is nearest the surface in relation to any portion of the workings of the mine; thus the back of the level is that part of the lode which is above.

Bar.—Term applied in Cornwall to a vein of a different description of mineral crossing the lode or country.

Beat away.—To excavate; a term usually applied to hard ground.

Bed.—A seam or horizontal deposite of ore.

Bend.—(*C.*)—Indurated clay; term applied by the miner to any hardened, argillaceous substance.

Black jack.—(*C.*)—Blende, sulphuret of zinc.

Blast.—The air introduced by the blowing apparatus into the furnace.

Blower.—(*C.*)—A smelter of ores.

Bounds.—(*C.*)—The limits of the ownership of a tract containing tin ore.

Brasque.—(*F.*)—A lining of closely-beaten charcoal, or other carbonaceous substance.

Branch.—A small vein which strikes out from the main lode, or branches from it.

Brood.—Impurities mixed with the ores.

Broil.—The traces of the presence of a lode found in the loose matter at or near the surface.

Buckers.—Men who break or bruise the ore.

Buddling.—Separating the ores from the mixture of earthy substances by means of a wooden frame or cistern filled with water.

Bunch.—A small quantity of ore in a compact mass in the vein.

Cal.—(*C.*)—Wolfram; tungstate of iron and manganese.

Cand.—(*C.*)—Fluor-spar.

Captain.—Superintendent of a mine.

Caunter (or contra) lode.—A lode forming an angle with the ordinary direction of the other lodes in its vicinity.

Champion lode.—The principal lode of a mine.

Clack.—The valve of a pump of any kind.

Cob.—To break up the ore with hammers, so as to sort out the valuable portion of it.

Cockle.—Schorl, or black tourmaline:

Coffin.—Old workings open to the day.

Comb.—The arrangement of the mineral contents of the lode in parallel, crystalline masses.

Cost-book system.—The method of working a mine according to certain regulations, by which the adventurers may at any time "sign off," and cease to be liable for any further expenditure in proving the mine. The plan is to insert in the "cost-book" the name and address of each of the adventurers who first work the mine, with all subsequent transfers of shares, and every expense attached to the undertaking; a meeting of the proprietors is held every two months, at which the purser presents his accounts, made up to that period, and the share-holders are thus enabled to judge of the state of the undertaking before incurring any further liabilities.

Country.—The strata or rock which the vein traverses; the rock in the neighborhood of the vein.

Course.—The direction of the vein.

Cross course.—A lode or vein which intersects another at a considerable angle, and which frequently throws the first out of its course.

Cross-course spar.—(*C.*)—Radiated quartz.

Cross cut.—A level driven at right angles with another to intersect the lode.

Crop.—The best ore.

Crop out.—To come to the surface; referring to strata.

Crush.—To grind the ores without water.

Cut.—To intersect by driving or sinking.

Costeaning.—Discovering the situation of a lode by sinking pits in its vicinity, and driving transversely to intersect it.

Covering.—Securing the shaft from the influx of water by ramming clay, &c., around the sides of the timber.

Dam.—(*C.*)—Choke damp; foul air.

Darrlinge.—(*G.*)—Residue of copper in the process of separating silver from copper in the liquation process.

Dead-work.—Work where the vein is not productive, or work which is done without obtaining any ore.

Deads.—Rubbish; attle; veinstone barren of ore.

Dialling.—Mining engineering; surveying within a mine.

Dish.—(*C.*)—That portion of the produce of a mine paid as rent to the owner or lord.

Dissueing.—Breaking down the strata from one of the walls of a rich and narrow vein, so that it can afterwards be taken down without loss or waste.

Dropper.—A branch which leaves the main lode.

Driving.—Excavating in a horizontal direction; opposed to sinking or excavating in a vertical direction.

Drift.—Horizontal excavation.

Dress.—To clean the ore by breaking off fragments of the gangue from the valuable ore.

Elvans.—(*C.*)—Dikes of granite and feldspar; porphyritic rocks cutting the slates and granites of Cornwall.

Engine-shaft.—The shaft by which the water is drawn from the lowest portion of the mine.

Feeder.—A branch falling into the main lode.

Fault.—A sudden interruption of the continuity of strata in the same plane, accompanied by a crack or fissure of a width varying from a mere line to several feet.

Flucan.—Decomposed, clayey matter, accompanying the slides and cross-courses, and sometimes the lode itself.

Foot-wall.—The wall on the lower side of the lode.

Gangue.—The non-metalliferous portion of the lode; the mineral substances accompanying the ore.

Gad.—A pointed wedge of a peculiar form, having its sides of a parallel figure.

Garkupfer.—(*G.*)—Refined copper.

Glist.—(*C.*)—Mica.

Good levels.—Nearly horizontal levels.

Gossan.—Oxide of iron, intermixed with quartz, generally found near the surface, in the lode or accompanying it.

Grass.—The surface; the open air.

Growan.—(*C.*)—Decomposed granite.

Ground.—The rock which is adjacent to the lode; the strata in which the lode occurs.

Gulph of ore.—A very large deposite of ore in the lode.

Hanging-wall.—The wall or side above the lode, in contra-distinction to the foot-wall.

Heave.—The horizontal dislocation which occurs when one lode is intersected by another having a different direction.

Horse.—The dead ground between two branches of a lode.

Joggling-table.—Inclined board, and which is made to move with a sudden and quick motion, used in washing the ores.

Jig.—To separate the ore with a riddle or wire-bottomed sieve, the heavier substance sinking to the bottom of the sieve

Junction.—Point where two veins, or different rocks, unite.

Keeve.—A large vat.

Kibble.—The bucket in which the ore and attle are sent to the surface.

Killas.—*(C.)*—Clay slate.

Kupfer-stein, (G.)—Regulus from coppery-lead ores twice roasted.

Lander.—The man who attends at the mouth of the shaft to receive the ores as they are sent to the surface.

Leader.—A branch of the main vein.

Levels.—Galleries driven on the lode at various depths, generally at intervals of ten fathoms.

Lifters.—Wooden beams to which the stamp-heads are fastened

Lode.—Regular vein producing ore.

Loupe.—*(F.)*—Bloom, from the puddling furnace.

Matte.—*(F.)*—Regulus, melted sulphuret.

Mock lead.—Blende, sulphuret of zinc.

Moor-stone.—*(C.)*—Granite.

Mundic.—*(C.)*—Iron pyrites.

Needle.—A long, tapering piece of copper used in tamping the hole for blasting, in order to leave a cavity for inserting the safety-fuse.

Pack.—To occasion the speedy subsidence of the ore in the process of tossing or chiming, by beating the keeve with a hammer.

Pair.—Gang, or party of men.

Parcel.—A heap of ore ready for sale.

Pass.—An opening left for letting down stuff to the level.

Peach.—*(C.)*—Chlorite.

Pick.—A common instrument for mining and agricultural purposes.

Pillar.—A piece of ground left to support the hanging wall.

Pitman.—One employed to look after the lifts of pumps and the drainage.

Pit work.—The pumps and other apparatus of the engine-shaft.

Point of the horse.—The spot where the lode splits or divides into two parts.

Pot grown.—*(C.)*—Soft decomposed granite.

Prian.—*(C.)*—Soft, white clay, esteemed in Cornwall a favorable sign, when found near a lode.

Rack.—An inclined frame on which ores are washed.

Riddle.—A sieve for washing the ores.

Rosette.—*(F.)*—Dish of refined copper taken off from the surface by throwing on cold water.

Run of a lode.—Its direction.

Saalbänd.—*(G.)*—Plural *saalbänder*, selvages, or thin bands of earthy matter, generally argillaceous, on each side of the vein next to the wall-rock.

Sett.—The portion of ground taken on lease for mining purposes.

Schlich.—*(G.)*—Finely pulverized ore mud.

Slag.—Silicious substances formed in the various processes of smelting and refining, principally silicates of the protoxide of iron, alumina, lime, and magnesia, generally containing a small portion of various metallic substances.

Shaft.—A vertical or inclined excavation in the lode or through the country.

Spleissofen.—*(G.)*—Copper refining furnace with two receivers for the fused metal.

Shears.—Apparatus for raising or lowering heavy articles in the shaft.
Shelf.—The solid rock.
Shoding.—Tracing the situation of a lode by means of the loose masses of ore and veinstone which have been separated from it and scattered in its neighborhood.
Shooting.—Blasting with gunpowder.
Sinking.—Excavating downwards in the shaft.
Slide.—A vertical dislocation of the lode.
Slickensides.—Polished, argillaceous surfaces of the rock, caused by the rubbing and grinding of large masses against each other.
Stockwerk.—(*G.*)—An assemblage of small irregular strings of ore, which has no regular form like a true vein, but in which the ore seems to have been disseminated through the fissures in the rocks.
Slimes.—Metallic ores mixed with finely-comminuted particles of the rock.
Smelt.—The reduction of metals from their ores by the aid of heat, in the usual metallurgic treatment in the large way, is called smelting.
Sollar.—The small platform at the end of a certain number of ladders.
Spalling.—Breaking up the rock into small pieces for the purpose of separating the ore.
Stamp.—To break up the ore and gangue by machinery, with the aid of water, for the purpose of washing out the heavier metallic particles.
Stamp-head.—The iron end of the beam which by its weight breaks the fragments of ore in the process of stamping.
Stope.—To excavate the space between two levels by a succession of step-like workings.
String.—A small vein.
Stuff.—Attle, or rubbish.
Sump.—The bottom of the engine-shaft, into which the water is allowed to run, and from which it is pumped or removed by some other means.
Tackle.—The windlass, rope, and kibble.
Tamping.—The substance with which the hole in blasting is filled after the charge of powder has been introduced; also, the process of filling the hole is called tamping.
Thrown.—A lode is said to be thrown up or down when it is intersected by a slide by which a portion of the lode has been removed from its original position to one side or the other.
Ticketings.—(*C.*)—The weekly public sales of ore.
Tribute.—The system of working by tribute is that under which the workman receives a certain proportion of the ore which he raises as a return for his labor.
Trunk.—A long narrow inclined box, in which the separation of the finely-washed ore from the earthy impurities is effected.
Tunnel-head.—The top of a furnace, where the materials are put in.
Tut-work.—Work in which the laborer is paid in proportion to the amount done—generally at so much per fathom in driving or sinking.
Tuyere.—Pipe through which the blast is introduced into the furnace.
Underlie.—The dip or deviation of a vein or bed from the perpendicular.
Van.—To cleanse a small portion of ore by washing away the earthy matter, by the aid of a shovel or some similar implement.

Vein.—The contents of a fissure in the rocks, of indefinite length and depth.

Vug.—*(C.)*—A cavity in the vein, generally lined with crystals.

Wall.—The side of the rocks adjacent to the vein.

Washing.—The process of separating the ore from the earthy impurities by the aid of water, the particles of ore and earthy matter arranging themselves in different positions according to their different specific gravities.

Whim.—A machine consisting of a drum revolving vertically by horse, steam, or water power, by which, with the aid of a rope and pulley, the ores are raised from the bottom of the mine.

Whim-shaft.—The shaft through which the ore is raised by means of a whim.

Whip and derry.—The simplest method of raising the kibble by means of a single pulley; the kibble is attached to a rope, which is drawn by a horse.

Winze.—A shaft sunk from one level to another, for ventillation, or for proving the vein. A winze differs from a shaft in not being open to the surface, like the latter.

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Plate I

MONTREAL RIVER FALLS

Plate II

Lith. 379 Broadway N.Y.

BIG BEKUENESEC FALLS, MENOMONEE RIVER.

Plate III

Ackerman Lith 379 Broadway N.Y.

CARP LAKE, PORCUPINE MTS.

Plate IV

Ackerman lith. 379 Broadway, N.Y.

COLUMNAR TRAP, ISLE ROYALE.

Plate V

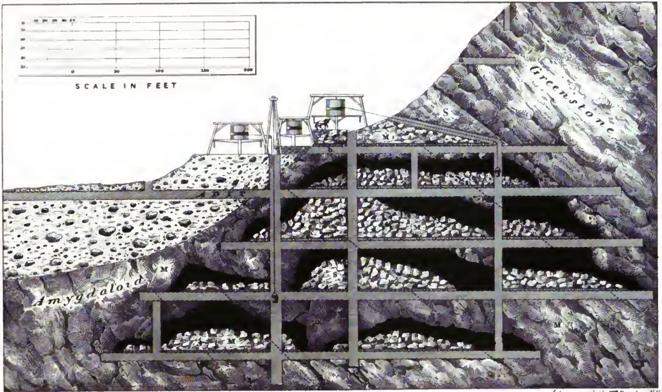
HORSE-SHOE, HARBOR L S

Plate VI

Ackerman Lith. 379 Broadway N.Y.

CONGLOMERATE HILLS NEAR F^T WILKINS

PLATE III

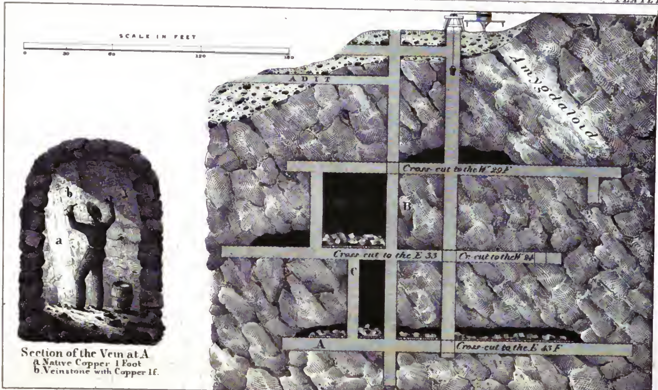


SECTION OF THE CLIFF MINE

Ackermann's Lith. 379 Broadway N.Y.

CLIFF MINE, LAKE SUPERIOR.

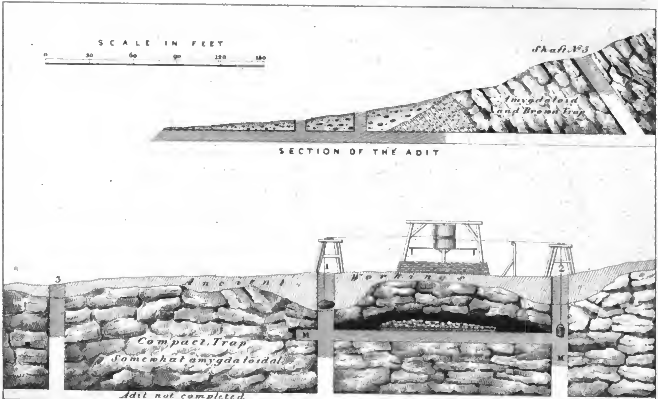
PLATE II



SECTION OF THE NORTH AMERICAN MINE.

Ackermann's Lith. 379 Broadway N.Y.

NORTH AMERICAN MINE LAKE SUPERIOR.



PLAN OF THF MINNESOTA MINE

Ackermann's Lith. 379 Broadway N.Y.

Pl. XII

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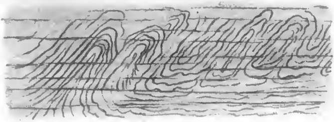

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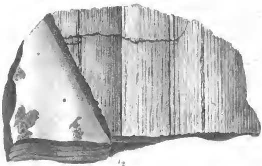

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